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Handbook

AUSTRALASIAN TRANSPORT RESEARCH FORUM 2021

8-10 DECEMBER 2021 | QUT GARDENS POINT

ATRF
AUSTRALASIAN TRANSPORT RESEARCH FORUM

CONTENTS

FORUM OFFICE

Before and After Forum:

c/- Absolute Events & Marketing
PO Box 584
Coorparoo Qld 4151

Phone: 07 3848 0089
Email: atrf@absoluteevents.com.au
Web: www.atrf2021.com.au

Absolute Events & Marketing
EXCEEDING EXPECTATIONS

During Forum:

For information and assistance at any time during the Conference, please see the staff at the Registration Desk or any of the Organising Committee members

Onsite Registration Desk
Room D-101, D Block
QUT Gardens Point Campus
George Street
Brisbane Qld 4000

Phone: 0450 006 224, 0404 488 910
Email: atrf@absoluteevents.com.au

WELCOME

On behalf of the Local Organising Committee, I welcome you to the Australasian Transport Research Forum 2021 (ATRF) being hosted in Brisbane (and virutally) by the Queensland University of Technology, Griffith University and The University of Queensland.

As the principal transport research conference in Australia and New Zealand, ATRF is dependent upon the number quality and depth of research papers.

With over 100 papers being submitted for ATRF 2021, we thank researchers andpresenters for their commitment to making this conference a success. You will see that program is filled with interesting presentations from keynote speakers, a wide range of breakout sessions on various topics, new technical streams and debates We therefore hope you will gain inspiration and education over the three days.

We are very grateful to the sponsors for their support – without which we could not have such an exciting program. I would like to thank the members of the local organising committee: Prof Matt Burke, Prof Alex Paz, Tom Frost, Abraham Leung, Prof Mark Hickman, Grant Solomon, Alban Pinz and Lucinda Hoffman. Finally I also thank Assoc Prof Doina Olaru and Assistant Prof Brett Smith of the ATRF Scientific Committee, supported by Amanda Eaton, for their untiring work in organising and co-ordinating papers and reviews.

Brendan O'Keeffe
Chair
Local Organising Committee

LOCAL ORGANISING COMMITTEE

Brendan O'Keeffe,
Principal Engineer, Policy and Strategy, Transport Planning and Operations, Brisbane Infrastructure, Brisbane City Council (Chair)

Prof Matthew Burke,
Professor, Cities Research Institute, Griffith University

Tom Frost, Director, NineSquared

Prof Mark Hickman,
Professor & Chair of Transport Eng, School of Civil Engineering, Faculty of Engineering, Architecture and Information Technology, The University of Queensland

Lucinda Hoffman,
General Manager (Strategic Policy), Department of Transport and Main Roads

Dr Abraham Leung,
Postdoctoral Research Fellow, Transport Research Group, Cities Research Institute, Griffith University

Prof Alexander Paz,
Professor and TMR Chair, School of Civil & Environmental Engineering, Faculty of Engineering, Queensland University of Technology

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PROGRAM

****PLEASE NOTE: ALL times shown are in AEST i.e. Brisbane, Queensland time - please adjust according to your own timezone****

WEDNESDAY 8 DECEMBER	
8.00am – 5.00pm	**Registration Desk Open** **Location:** D-101
8.00am – 9.00am	**Coffee & Networking** **Location:** D-101
9.00am – 10.30am	**Opening Plenary** **Chair:** Brendan O'Keeffe **Room:** D-301
9.00am – 9.15am	**Forum Welcome and Acknowledgement of Country**
9.15am – 9.35am	**Opening Address: COVID has been a disruptor to the way we move people goods and services around our cities and around the world (P01)** The Hon Mark Bailey MP, Queensland Minister for Transport and Main Roads
9.35am – 10.15am	**What is the value of Strategic Transport Models in the next normal? Some clues as to enhancements required to recognise the changing landscape (P02)** Prof David A. Hensher: Professor and Founding Director, Institute of Transport and Logistics Studies, The University of Sydney
10.15am – 10.30am	**Housekeeping**
10.30am – 11.00am	**Morning Tea** **Location:** D-101

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WEDNESDAY 8 DECEMBER (CONTINUED)				
11.00am – 12.20pm	**Concurrent Session 1**			
	Session 1A: Active Transport	**Session 1B: Public Transport**	**Session 1C: Traffic Modelling**	**Session 1D: Economics**
	Room: D-101	**Room:** D-301	**Room:** D-304	**Room:** D-307
	Chair: Fay Golbabaei, QUT	**Chair:** Benjamin Kaufman, GU	**Chair:** Matthew Burke, GU	**Chair:** Shubham Sharma, QUT
11.00am – 11.20am	**Evaluating the impacts of personal mobility devices (e-scooters) in Central Brisbane (38)** Rhiannon Pace and Michael Pollard, Queensland University of Technology	**Australia's long distance passenger train and coach services: international comparisons (33)** Phil Potterton, Economic Connections	**Combining multiple traffic data sources to estimate Macroscopic Fundamental Diagram in large-scale 3 urban networks (36)** Elham Saffari, The University of Queensland	**Assessing Toll Road Demand in New Zealand (122)** Neil Douglas, Douglas Economics
11.20am – 11.40am	**Influence of walking accessibility on older people walking preference (54)** Kaniz Fatima, RMIT University	**The impact of bus network reform on the resilience of Melbourne's public transport system (62)** Ian Woodcock, Swinburne University of Technology	**Estimation of origin-destination flows in large scale traffic networks (41)** Sakitha Kumarage, The University of Queensland	**The development and application of a land use, transport and economy interaction model (71)** Henry Le, AECOM
11.40am – 12.00pm	**Brisbane's developments in e-mobility (74)** Brendan O'Keeffe, Brisbane City Council	**Neighbourhood typology and bus use: A simplified approach to predict bus demand (32)** Jeyashivraj Parthiban, Wellington Shire Council	**Network-wide traffic simulation with multi-agent imitation learning (61)** Jie Sun, The University of Queensland	**Optimal toll charges for multi-class vehicles in City Logistics (28)** Loshaka Perera, University of Moratuwa
12.00pm – 12.20pm	**Empirical identifiability of Latent Class Models: Theoretical analysis and application to multiple heuristics modelling (72)** Felipe Gonzalez-Valdes, Pontifica Universidad Católica de Chile	WITHDRAWN	**Traffic Forecasting in a Freeway Corridor using Seasonal ARIMA Model** Mahmuda Akhtar, RMIT University (117)	
12.20pm – 1.10pm	**Lunch** **Location:** D-101			

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WEDNESDAY 8 DECEMBER (CONTINUED)

1.10pm – 1.55pm	**Debate: That micromobility is good for cities** **Chair:** Matthew Burke **Room:** D-301			
	The rise of small electric bikes, scooters, and skateboards has started transforming urban travel in Australian cities. Queensland now has public e-scooter sharing systems in cities as diverse as Townsville, Bundaberg, Hervey Bay and Brisbane. But is this 'micromobility' revolution good for cities? **Participants:** Dr Abraham Leung, Griffith University Brendan O'Keeffe, Brisbane City Council			
1.55pm – 2.00pm	**Room Change**			
2.00pm – 3.20pm	**Concurrent Session 2**			
	Session 2A: Demand Modelling	**Session 2B: Freight**	**Session 2C: Big Data**	**Session 2D: COVID**
	Room: D-101	**Room:** D-301	**Room:** D-304	**Room:** D-307
	Chair: Yiping Yan, GU	**Chair:** Mark Hickman, UQ	**Chair:** Dan He, UQ	**Chair:** Prithvi Beeramoole, QUT
2.00pm – 2.20pm	**A new employment market segmentation-'purple collar' for transport models, a case study in South-East Queensland, Australia (127)** Yiping Yan, Griffith University	**Australian Road Freight – Measuring and Modelling (23)** David Gargett, Bureau of Infrastructure and Transport Research Economics	**Data-driven Traffic Incident Prediction with Hybrid Graph-based Neural Network (58)** Thanh Tran, The University of Queensland	**The Impacts of COVID-19 Pandemic on The Volume and Pattern of Public Transport Trips in The Greater Sydney Area (45)** Seyed Sina Mohri, University of Melbourne
2.20pm – 2.40pm	**Do digital natives telework more than digital immigrants? (60)** Yu-Tong Cheng, University of Melbourne	**Freight modelling in Australia in 2021 – A data availability perspective (88)** Caitlin McHugh, Veitch Lister Consulting	**Pavement Monitoring: A Comparison of Smartphone and Accelerometer sensors (77)** Amir Shtayat, RMIT University	**The impact of working from home on travel demand: a methodology and preliminary estimates from Victoria (49)** Tim Bryant, Victorian Department of Transport
2.40pm – 3.00pm	WITHDRAWN	**Predicting freight demand for planning loading docks (50)** Russell Thompson, University of Melbourne	**Multi-Level Trajectory Clustering for Identifying Path Choice Set (85)** Chintan Advani, Queensland University of Technology	**Pedestrian activity in Melbourne, Australia in response to COVID-19 (40)** Mahsa Naseri, Monash University
3.00pm – 3.20pm	**The influence of weather on bus ridership for different passenger types in Canberra, Australia (92)** Emily Moylan, The University of Sydney	**Planning for urban freight through loading dock provision in new developments (51)** Michael Stokoe, Transport for NSW		
3.20pm – 3.40pm	**Afternoon Tea** **Location:** D-101			

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WEDNESDAY 8 DECEMBER (CONTINUED)				
3.40pm – 4.40pm	**Concurrent Session 3**			
	Session 3A: Social/Economic	**Session 3B: Public Transport**	**Session 3C: New Technology, attitudes and behaviour**	**Session 3D: Transport History**
	Room: D-101	**Room:** D-301	**Room:** D-304	**Room:** D-307
	Chair: Kelly Bertolaccini, GU	**Chair:** Madison Bland, GU	**Chair:** Zeke Ahern, QUT	**Chair:** Matthew Burke, GU
3.40pm – 4.00pm	**The lived experience of transport limitations in Melbourne's growth areas (57)** Annette Kroen, RMIT University	**Beyond prohibition: policy options for pets on public transport (79)** Jennifer Kent, The University of Sydney	**Attitudes towards automated vehicles: a Dutch-Australian comparison (24)** Tony Arnold, The University of Sydney	**Observations on electric vehicle's first hurrah - horse, steam and electric tramway technology adoption rates in the UK 1860s to 1960s (108)** Robert Smith, East Economics
4.00pm – 4.20pm	**The Logan DRT Trial: Socio-demographic analysis of users (19)** Ben Kaufman, Griffith University	**Research issues arising from a review of themes at the formal-informal transport interface in developing countries (105)** David Ashmore, TSA and University of Melbourne	**How Governments Influence Autonomous Vehicle (AV) Innovation (34)** Doina Olaru and Brett Smith, University of Western Australia	**Overcoming the Brisbane River: The Cross River Commission of 1926 (75)** Brendan O'Keeffe, Brisbane City Council
4.20pm – 4.40pm			**Decision field theory: an extension for real-world settings (70)** Thomas O. Hancock, University of Leeds	**A Retrospective on the Adelaide Area Transportation Study (13)** Robert Nairn
4.40pm	**Close Day One**			
6.00pm – 7.30pm	**Welcome Reception** (Sponsored by Griffith University) Ship Inn, South Bank			Griffith UNIVERSITY Queensland, Australia Cities Research Institute

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THURSDAY 9 DECEMBER	
8.00am – 5.00pm	**Registration Desk Open** **Location:** D-101
8.00am – 9.00am	**Coffee & Networking** **Location:** D-101
9.00am – 10.25am	**Plenary 2** **Chair:** Alexander Paz **Room:** D-301
9.00am – 9.10am	**Day 2 Welcome**
9.10am – 9.35am	**The Future of Transport in Brisbane (P03)** Cr Ryan Murphy, Civic Cabinet Chair for Transport, Brisbane City Council
9.35am – 10.00am	**Artificial Intelligence and F1 Grand Prix - What's that got to do with Intelligent Network management (P04)** Dr Kellie Nuttall, Partner, Deloitte Australia
10.00am – 10.25am	**Update on Australian Transport Assessment & Planning Guidelines (P05)** Dr Peter Tisato, Technical Coordinator, Australian Transport Assessment & Planning Guidelines
10.25am – 11.00am	**Morning Tea** **Location:** D-101

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THURSDAY 9 DECEMBER (CONTINUED)				
11.00am – 12.20pm	**Concurrent Session 4**			
	Session 4A: Active Transport	**Session 4B: Public Transport**	**Session 4C: Traffic Modelling**	**Session 4D: Economics**
	Room: D-101	**Room:** D-301	**Room:** D-304	**Room:** D-307
	Chair: Shubham Sharma, QUT	**Chair:** Maisie Rahbar, UQ	**Chair:** Jie Sun, UQ	**Chair:** Abraham Leung, GU
11.00am – 11.20am	**Transport as recreation - Road sharing in regional Victoria (43)** Robbie Napper, Monash University	**The catalytic effects of public transport infrastructure on urban renewal: the case of level crossing removal projects in Melbourne (118)** Abdulrhman Gbban, Monash University	**Modelling network-wide travel time variability: A case study (96)** Elnaz Irannezhad, ARRB	**BCR: Benefit Cost Ratio or Barely Capturing Reality? (89)** Anthony Vine, NineSquared
11.20am – 11.40am	**Maintaining shared automobile, bicycle, and pedestrian facilities: Towards a multi-objective approach (103)** Sue McNeil, University of Delaware	WITHDRAWN	**Maximum queue length estimation at signalized intersections using shockwave theory and Kalman filter (46)** Wanuji Abewickrema, The University of Queensland	**Valuing Life when Roads are Increasingly Safe (126)** Neil Douglas, Douglas Economics
11.40am – 12.00pm	**A GIS-based Walkability Analysis for the Greater Adelaide Metropolitan Area: An Evaluation of the AURIN Walkability Index (109)** Arsham Bassiri Abyaneh, University of South Australia	**How can we build trust and collaboration among the stakeholders in a MaaS eco-system? (53)** Thiranjaya Kandanaarachchi, The University of Sydney	**Tourists, Visitors and Urban Modelling (16)** Robert Nairn	**Accounting for the social benefits of regional transport investments – A case study from the Great Western Highway Upgrade Program (97)** Lee Jollow and Kapil Kulkarni, RPS
12.00pm – 12.20pm	**Network Assessment for Cycling, the Inner Adelaide Case (37)** Ali Soltani, University of South Australia			
12.20pm – 1.20pm	**Lunch (Sponsored by NineSquared)** **Location:** D-101			
1.20pm – 2.10pm	**Debate: That Sports Events Create a Great Transport Legacy** **Chair:** Tom Frost **Room:** D-301			
	For many years cities have competed for the right to host major sporting events with the expectation that they will leave a legacy of urban regeneration and improved transport infrastructure, but is this expectation justified?			
	For the Affirmative: • Barry Gyte, *Gyte Consulting* • Jane Hornibrook, *Hornibrook Consulting*		**For the Negative:** • Prof Matthew Burke, *Griffith University* • Anthony Vine, *NineSquared*	

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THURSDAY 9 DECEMBER (CONTINUED)				
2.10pm – 3.30pm	**Concurrent Session 5**			
	Session 5A: Demand Modelling	**Session 5B: Freight Modelling / Economics**	**Session 5C: Big Data / Pavements**	**Session 5D: COVID**
	Room: D-101	**Room:** D-301	**Room:** D-304	**Room:** D-307
	Chair: Fay Golbabaei, QUT	**Chair:** Christopher Johnson, GU	**Chair:** Dan He, UQ	**Chair:** Zeke Ahern, QUT
2.10pm – 2.30pm	**Can partial structural information of travel demand improve the quality of OD matrix estimates? (120)** Krishna Behara, Queensland University of Technology	**Multimodal network routing problem using Multimodal Leg Outcome (MLO) table (115)** Surya Prakash, University of the South Pacific, Fiji	**Mindfulness and commuting to campus: Pilot study from Monash University (87)** Alexa Delbosc, Monash University	**The Implications of Working-from-home for transportation: literature review (83)** Brett Smith, University of Western Australia
2.30pm – 2.50pm	**Recalibrating travel demand models using Census data and household travel survey data from other jurisdictions: A case study of Greater Adelaide (100)** Ali Ardeshiri, University of South Australia	**Rethinking rail freight access: developing a new policy agenda (129)** Phil Bullock and Tom Frost, NineSquared	**A data-driven approach to benchmark route choice 1 set generation algorithms (107)** Chintan Advani, Queensland University of Technology	**The impact of COVID-19 pandemic on parcel delivery pattern in Sydney (67)** Masoud Kahalimoghadam, The University of Melbourne
2.50pm – 3.10pm	**Reducing car use without changing mode (130)** Elizabeth Ampt, Concepts of Change	**Stakeholder decisions shaping urban freight (27)** Loshaka Perera, University of Moratuwa	**A Comparison Study of Different Data Resolutions for Deep Reinforcement Learning Based Adaptive Traffic Signal Control System (59)** Mobin Yazdani, University of Melbourne	**Lockdowns and Lags: Lessons from the effect of COVID-19 on the Perth transportation system (125)** Tristan W. Reed, Curtin University
3.10pm – 3.30pm	**Modelling small-area electric vehicle uptake across Australia (86)** David Mitchell and Robert Monterosso, Bureau of Infrastructure and Transport Research Economics		**Impacts of Autonomous Vehicles on Road and Pavement Design (113)** Long Truong, La Trobe University	
3.30pm – 3.50pm	**Afternoon Tea** **Location:** D-101			

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THURSDAY 9 DECEMBER (CONTINUED)				
3.50pm – 4.50pm	**Concurrent Session 6**			
	Session 6A: Social / Economic	**Session 6B: Safety**	**Session 6C: New Technology**	**Session 6D: History**
	Room: D-101	**Room:** D-301	**Room:** D-304	**Room:** D-307
	Chair: Chintan Advani, QUT	**Chair:** Madison Bland, GU	**Chair:** Prithvi Beeramoole, QUT	**Chair:** Benjamin Kaufman, GU
3.50pm – 4.10pm	**Planning with Country: Has the transport profession begun the journey? (64)** Eric Keys, RMIT University	**A conceptual approach towards the evaluation of the vulnerability of urban railway network infrastructure by analysing railway accident reports (31)** Wei-Ting Hong, The University of Sydney	**The Potential Impact of Informational Cues on Willingness-to-Pay for Driverless Cars (20)** Milad Ghasri, University of NSW	**Australian Transport planning in the 1970s (14)** Robert Nairn
4.10pm – 4.30pm	**Age, Transport, and Technology: Older Queenslanders' travel behaviours and use of transport-related technology (66)** Kelly Bertolaccini, Griffith University	**On the transferability of traffic conflict-based safety assessment methods: A case of crash frequency-by-severity prediction models (29)** Md Mazharul Haque, Queensland University of Technology	**Framework for field evaluation of signal cooperative intelligent transport system use cases as based on the Ipswich Connected Vehicle Pilot (91)** Joshua Elder, Queensland University of Technology	**Lies, Damned Lies and Statistics (21)** Alex Wardrop
4.30pm – 4.50pm	**Exploring a Social Licence to Operate the Road System (22)** William Young, Monash University	**Dynamic Assessment of Regulation and Policy Framework in the Cybersecurity of Connected and Autonomous Vehicles (124)** Shah Khalid Khan, RMIT University	**Planning for the electrification of Australasian road transport (26)** Tim Brooker, EMM Consulting	**Evolution of Sydney's Bus Network: 1925 to 2020 (99)** Hema Rayaprolu, The University of Sydney
4.50pm	**Close Day Two**			

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FRIDAY 10 DECEMBER				
8.00am – 1.30pm	**Registration Desk Open** **Location:** D-101			
8.00am – 9.00am	**Coffee & Networking** **Location:** D-101			
9.00am – 10.20am	**Concurrent Session 7**			
	Session 7A: Demand Modelling/ Safety	**Session 7B: New Technology**	**Session 7C: COVID**	**Session 7D: Economics**
	Room: D-101	**Room:** D-301	**Room:** D-304	**Room:** D-307
	Chair: Yiping Yan, GU	**Chair:** Maisie Rahbar, UQ	**Chair:** Mark Hickman, UQ	**Chair:** Matthew Burke, GU
9.00am – 9.20am	**Can a metaheuristic be used to assist in discrete choice modelling? (104)** Prithvi Bhat Beeramoole, Queensland University of Technology	**Can MaaS change users' travel behaviour to deliver commercial and societal outcomes? (30)** Chinh Ho, The University of Sydney	**Pandemics and Urban Travel – Lessons for COVID-19 from the 1918-1920 Spanish Flu (73)** Graham Currie, Monash University	**Moving international shipping containers at seaports: A case study for Melbourne (35)** Dimitris Tsolakis, DT Consulting
9.20am – 9.40am	**Analysis of Head-on Heavy Vehicle Crashes in Queensland using Correlated Random Parameters with Heterogeneity in Means and Lindley (132)** Krishna Behara, Queensland University of Technology	**The commercial viability of Mobility-as-a-Service (MaaS): What's in it for existing transport operators, and why should governments intervene? (111)** Akshay Vij, University of South Australia	**How does the built environment shape active travel during COVID-19 travel restrictions? Evidence from Melbourne (42)** Mahsa Naseri, Monash University	**Crowding Costs and Expansion Factors for Sydney's Heavy Rail Network (76)** Alexander Svanberg, Transport for NSW
9.40am – 10.00am	**Crash risks during mandatory lane-changing manoeuvres in a connected environment (39)** Yasir Ali, Queensland University of Technology	**The prospects for Tourism-focused MaaS in Queensland (128)** Abraham Leung, Griffith University	**Implications of remote working for commute travel patterns in Australia (112)** Akshay Vij, University of South Australia	**'When the bough breaks': critical question for the crafting of Australia's bus franchises in the era of electric fleet (102)** David Ashmore, TSA Advisory
10.00am – 10.20am		**Do Trackless Trams need stronger roads? – the "weight" of evidence (80)** James Reynolds, Monash University	**Changing Work Practices, Active Travel, Health and Well-being during a Pandemic (134)** Stephen Greaves, The University of Sydney	**Global Market Appetite for Metro Rail (17)** Brendon Baker, Mott MacDonald

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FRIDAY 10 DECEMBER (CONTINUED)				
10.20am – 10.40am	**Morning Tea** **Location:** D-101			
10.40am – 11.40am	**Concurrent Session 8**			
	Session 8A: Social/Economic	**Session 8B: Urban Design**	**Session 8C: Traffic Modelling**	**Session 8D: Safety**
	Room: D-101	**Room:** D-301	**Room:** D-304	**Room:** D-307
	Chair: Abraham Leung, GU	**Chair:** Chintan Advani, QUT	**Chair:** Jie Sun, UQ	**Chair:** Kelly Bertolaccini, GU
10.40am – 11.00am	**Birds and Roads: A Longitudinal Study of a Major Road Project in SEQ (48)** Christopher Johnson, Griffith University	**Estimating location choice models in Australia (114)** Stuart Donovan, Vrije Universiteit Amsterdam	**An overview of dynamic traffic assignment models in practice (94)** Elnaz Irannezhad, ARRB	**Emergency search plan for complex premises (44)** Saeed Asadi Bagloee, University of Melbourne
11.00am – 11.20am	**Measuring the distributive impacts of electric vehicle policies (133)** Vincent Benezech, Veitch Lister Consulting	**Lessons for Adopting Microeconomic Land Use Models at the City Scale: Perth Case Study (116)** Doina Olaru, University of Western Australia	**Car Following Modelling with Constrained Generative Adversarial Imitation Learning (69)** Lin Lin, The University of Queensland	**Efficient Estimation of Crash Count Data via Meat-heuristic Solution Algorithm (90)** Zeke Ahern, Queensland University of Technology
11.20am – 11.40am		**Understanding the allocation and use of street space in activity centres (18)** Chris De Gruyter, RMIT University	**Modelling Travel Time Variability within Transport Networks: A Practitioner Oriented Approach (95)** Elnaz Irannezhad, ARRB	
11.40am – 11.45am	**Move to closing plenary room D-301**			
11.45am – 12.30pm	**Closing Plenary: Paper Prizes** **Chair:** Brendan O'Keeffe **Room:** Room D-301			
	Paper Prizes **Best Transport Modelling Paper Award** **Presented by:** Prof David A. Hensher Professor and Founding Director, Institute of Transport and Logistics Studies **John H Taplin Best Paper Award** **David Willis Best Student Paper Award** **Presented by:** Doina Olaru, Co-Chair, ATRF Scientific Committee			
	Conference wrap-up and announcement of ATRF 2022 Brendan O'Keeffe, ATRF 2021 Conference Chair and Lindsay Oxlad, ATRF 2022 Convenor and Prof Rocco Zito, ATRF 2022 Host University			
12.30pm – 1.30pm	**Lunch** **Location:** D-101			

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FRIDAY 10 DECEMBER (CONTINUED)	
3.30pm – 5.00pm	**Tours** (Attendees to make their own way to meeting point)
	Cross River Rail and Brisbane Metro Briefing on the Cross River Rail project **Host:** Jordan Haimes, Community Engagement Officer, Cross River Rail Development Authority **Meeting Point:** Cross River Rail Experience Centre, Level 1/151 Elizabeth Street, Brisbane City
	Neuron e-mobility Showing behind the scenes operations of the Neuron Mobility **Host:** Dale Sinkowski, Brisbane City Operations Manager **Meeting Point:** Goodwill Bridge entry, QUT Gardens Point Campus. Tour ends at Neuron Mobility warehouse in Milton.

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NETWORKING EVENTS & TOURS

WELCOME RECEPTION

Sponsored by

Griffith UNIVERSITY Queensland, Australia
Cities Research Institute

When: Wednesday 8 December
Time: 6.00pm – 7.30pm
Includes: Beverages and canapes
Where: The Ship Inn, South Bank (Corner of Sidon & Stanley Streets, South Bank Parklands)
Guests to make their own way to The Ship Inn – the function room is upstairs

CROSS RIVER RAIL AND BRISBANE METRO

Briefing on the Cross River Rail project

When: Friday 10 December
Time: 3.30pm – 5.00pm
Host: Jordan Haimes, Community Engagement Officer, Cross River Rail Development Authority
Meeting Point: Cross River Rail Experience Centre, Level 1/151 Elizabeth Street, Brisbane City.

NEURON E-MOBILITY

Showing behind the scenes operations of the Neuron Mobility

Sponsored by

neuron

When: Friday 10 December
Time: 3.30pm – 5.00pm
Host: Dale Sinkowski, Brisbane City Operations Manager
Meeting Point: Goodwill Bridge entry, QUT Gardens Point Campus.
Tour ends at Neuron Mobility warehouse in Milton.

KEYNOTE SPEAKERS

The Hon Mark Bailey MP
Queensland Minister for Transport and Main Roads

Biography

Mark Bailey is Queensland's Transport and Main Roads Minister in the Palaszczuk Labor Government and the local member for Miller. His portfolio oversees Australia's largest state-controlled road network (at over 33,000kms), along with 19 state-owned ports and Queensland's urban and freight rail network.

Mr Bailey was elected to the Queensland Parliament in January 2015. He has delivered five record road and transport budgets for Queensland, with major projects including the largest jointly-funded road upgrade program in the state: the $12.6 billion Bruce Highway upgrade program, the government's largest rail project Cross River Rail, $5 billion to upgrade the M1 and build the second M1, Gold Coast Light Rail Stage 3 to Burleigh Heads and the Sunshine Coast Rail duplication.

Mr Bailey has also delivered major innovations in transport and roads, with record investment in bike, active transport and pedestrian safety upgrades, the creation of Australia's largest electric vehicle charging network: the Queensland Electric Super Highway and works to create a statewide $371 million smart ticketing system for public transport.

The Minister recognises the significance of his portfolio as a key facilitator for economic development across Queensland and as part of the state's economic recovery plan from COVID-19, with a record $26.9 billion roads and transport budget expected to support 23,600 jobs, including more than 16,000 for regional Queensland.

Professor David Hensher
Professor and Founding Director, Institute of Transport and Logistics Studies

Biography

Professor David Hensher is Founding Director of the Institute of Transport and Logistics Studies at The University of Sydney. He also co-founded the Thredbo International Conference Series on Competition and Ownership in Passenger Transport. A Fellow of the Australian Academy of Social Sciences; recipient of numerous awards including the 2009 International Association of Travel Behaviour Research (IATBR) Lifetime Achievement Award and the 2019 John Shaw Medal which honours an industry champion who has made a lasting contribution to Australia's roads. David has published over 700 papers in leading international journals as well as 16 books and has a Google scholar citation index of 65,000.

Overview

This plenary address takes a bird's eye perspective on strategic transport model systems (STMS), highlighting some of the key features that should be embedded in progressive STMSs, many of which are given light treatment. We then focus on two themes – how to embed working from home into STMSs and what are some of the important policy themes that such modelling should address in the next normal as a way of questioning the currency of such modelling systems used by all State governments.

KEYNOTE SPEAKERS

Councillor Ryan Murphy
Civic Cabinet Chair for Transport,
Brisbane City Council

Biography

Cr Ryan Murphy is the Civic Cabinet Chair for Transport and the Councillor for Chandler Ward. Cr Murphy oversees a number of Council's major projects including the $1.24Bn Brisbane Metro and $550M Green Bridges program, as well as Brisbane's bus, ferry and CityCat fleet. He is responsible for the Transport for Brisbane network which carries 78 million passengers annually. Cr Murphy also leads the rollout of the city's innovative e-mobility program and Council's record investment into bicycle infrastructure projects. He is committed to shaping Brisbane into a leader in sustainable, high quality public and green transport.

Overview

The Schrinner Council is currently embarking on Brisbane's largest ever investment in public and green transport, including the game-changing Brisbane Metro project and new green bridges at Kangaroo Point, Breakfast Creek and West End. The future of transport in Brisbane is human-centred mobility – from Brisbane Metro's public realm improvements, to Australia's first shared e-mobility scheme and an iconic, modern river ferry network – all of which will support the Brisbane 2032 Olympic Games.

Dr Kellie Nuttal
Lead Partner for Artificial
Intelligence Practice, Deloitte

Biography

Kellie is the lead Partner for the Artificial Intelligence Practice at Deloitte and specialises in the Future of Mobility and smart cities. She has authored several global Deloitte Insights papers regarding the role of government in the Future or Mobility. She is also a Faculty member of Singularity University focused on harnessing exponential technologies to support improved transport system and customer outcomes - Specifically in the domain of AI and Digital Twins. She has worked with many state and federal government clients on their AI and Digital Twin programs over the past 2 years from business case development through to prototypes and productionising digital twin and AI technologies.

Overview

Digital Twins have been two buzz words dropped readily into conversations about the future of intelligent network planning and operations.... but what are they, what do they do, and how good are they really in a transport context?

In this keynote, learn how applications of digital twins supported by advanced simulation and AI in other sectors like F1 and aviation are now finding value on the ground in managing complex multimodal transport networks.

KEYNOTE SPEAKERS

Peter Tisato
Technical Coordinator, Australian Transport Assessment & Planning Guidelines

Biography

Peter Tisato is the Technical Coordinator for the Australian Transport Assessment and Planning (ATAP) Guidelines, reporting to the ATAP steering committee. His education and training have been in economics, planning and engineering. He has over 40 years of experience, primarily in transport policy, planning and project appraisal. He has been associated with the ATAP Guidelines since their initiation in 2004.

Overview

The Australian Transport Assessment and Planning (ATAP) Guidelines (known as the National Guidelines for Transport System Management before 2016) have played an important role since 2004 when they were first published. In September 2021 a number of new and updated pieces of ATAP guidance were published. Following the completion of a review in 2021, a new program for maintaining and improving the Guidelines has recently commenced. The paper will provide an over of these recent developments.

GENERAL INFORMATION

CATERING

Arrival tea/coffee, morning and afternoon teas and lunch will be served in Room D-101 (Ground Floor, D Block).

DIETARY REQUIREMENTS/FOOD ALLERGIES

Any attendee who advised a dietary requirement or food allergy will have a dietary card in their name tag pocket. The caterer has been advised of this request so please identify yourself to the catering staff at the meal breaks. While the caterers will aim to cater to any special dietary meals advised onsite, please be aware that, due to the late notification, it may not be possible.

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DRESS CODE

Smart attire is appropriate for all Forum sessions and social functions. Please be aware the session room is airconditioned while the catering area is not airconditioned.

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In the unlikely event of an emergency, individuals should following the directions of Forum Organising and QUT staff. In case of fire, attendees are asked to assemble at designated spots outside the venue (see venue map)

LIABILITY

Neither the Forum Organiser nor the Organising Committee accepts any responsibility for loss or damage, theft, injuries/accidents or any other relevant matters. Attendees should make their own arrangements with respect to personal insurance.

NAME BADGES

Attendees are required to wear their name badge at all times as they allow access to all Forum sessions and catering. Those not wearing name badges will be asked to see Registration Desk staff for re-issue.

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Attendees should be aware that smoking is banned within the venue. Designated smoking areas are clearly signed. Please be aware that, due to heavy fines, food and beverage is not allowed to be consumed in these designated smoking areas.

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PEOPLE WITH A DISABILITY

Should you require assistance, please advise the Forum Organisers and we will do all we can to make your attendance as comfortable as possible. The Forum venue is a fully accessible venue.

REGISTRATION DESK

The registration desk is located in Room D-101, Ground Floor, D Block and will be open during the following times:

8.00am – 5.00pm
Wednesday 8 and Thursday 9 December 2021

8.30am – 1.30pm
Friday 10 November 2021

Please contact staff at this desk with any queries. For enquiries outside of these times, please contact the Forum Management Team:

0450 006 224 – Amy Mailander, Forum Co-Ordinator
0404 488 910 – Susan Harris, Forum Manager

VENUE MAP

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ABSTRACTS
WEDNESDAY 8 DECEMBER 2021

OPENING PLENARY

9.15am – 9.35am

Opening Address: COVID has been a disruptor to the way we move people goods and services around our cities and around the world (P01)

***The Hon. Mark Bailey**, Queensland Minister for Transport and Main Roads,*

9.35am – 10.15am

What is the value of Strategic Transport Models in the next normal? Some clues as to enhancements required to recognise the changing landscape (P02)

***Prof David Hensher**, Professor and Founding Director, Institute of Transport and Logistics Studies, The University of Sydney*

This plenary address takes a bird's eye perspective on strategic transport model systems (STMS), highlighting some of the key features that should be embedded in progressive STMSs, many of which are given light treatment. We then focus on two themes – how to embed working from home into STMSs and what are some of the important policy themes that such modelling should address in the next normal as a way of questioning the currency of such modelling systems used by all State governments.

SESSION 1A: ACTIVE TRANSPORT

Evaluating the impacts of personal mobility devices (e-scooters) in Central Brisbane [38]

***Rhiannon Pace** (Queensland University of Technology), **Michael Pollard** (Queensland University of Technology), **Jonathon Bunker** (Queensland University of Technology) and **Jeffrey Baczynski** (SLR Consulting Australia Pty Ltd)*

Abstract

The popularity and demand for e-scooters in Brisbane, Australia has continued to grow since their adoption in 2018. This paper presents the findings to date of a research project which aims to evaluate the impacts associated with these devices in Central Brisbane. So far, it is evident that there is a lack of research surrounding the impacts of e-scooters across Australia, from both a safety and an operational perspective. Recently there has been an increase in crash data analysis relating to e-scooters in Brisbane but there is still limited research on these devices, specifically research that considers both safety and operation together. The State of Queensland has classified e-scooters as personal mobility devices and hence riders are considered as pedestrians. This limits the infrastructure on which they can be used and currently they are not legally permitted to be ridden on on-road cycle lanes or roads other than local roads with speed limits less than 50km/h. The adoption of these devices varies substantially between Australian states, from New South Wales which has banned these devices on public land, to Queensland which has the least restrictive laws. While only the state has regulatory authority over whether/how devices are operated by the rider, local government may restrict or support the presence of devices on its land and/or infrastructure. Consequently, uptake of e-scooters has created a user class whose implementation and management are dependent on both levels of government working together. It has also been evident that crash data relating to e-scooters is difficult to ascertain,

with much of the existing e-scooter crash research informed by hospital admissions data. Based on the information found so far, we have developed a questionnaire and observational survey to further understand existing opinions on the devices, and the existing safety and operational impacts of the devices respectively.

Influence of walking accessibility on older people walking preference [54]

Kaniz Fatima *(RMIT University) and* ***Sara Moridpour*** *(RMIT University)*

Abstract

Travel behaviour models are necessary to identify travel demand and planning transport systems. Many studies identify various approaches to measure walking accessibility and travel behaviour modelling. However, a limited model is developed to analyse the older peoples' walking as a transport mode preference based on travel time, population and spatial area. This study presented a binary logistic regression model to observe the older commuters' transport mode preference. This research examines four major travelled destinations (shopping centres, health care centres, education centres and recreational centres) for the elderly. The framework of this study complies with three parts. Firstly, the study develops a walking accessibility index for older commuters to observe the access level. Afterwards, several numbers of the various binary model are evaluated and compared. The binary models are developed using older commuters'' walking accessibility index, socio-economic (gender, relation, car license, car numbers, income, disable parking permit, dwelling type, dwell ownership) and built-in environmental (home sub-region, land mix use) variables. Finally, the best fit model is validated using statistical methods (Omnibus test, Hosmer and Lemeshow test). Moreover, the probabilities of selecting walking as a transport mode by older travellers are analysed by statistical model and compare with actual travel survey datasets. The results confirm that the proposed time-based model can describe the older commuters'' travel decisions. The proposed walking accessibility index and the preference model can be helpful to plan distributions of essential destinations coverage. Future urban and policy planners can use the walking preference to evaluate older peoples'' walking access towards different destinations.

Brisbane's developments in e-mobility [74]

Brendan O'Keeffe *(Brisbane City Council) and* ***Tarni Callaghan*** *(Brisbane City Council)*

Abstract

Changes in Queensland transport legislation in 2018 generated a revolution in short distance inner city transport by allowing a wider range of small devices known as personal mobility devices to be used. The use of these devices collectively known as e-mobility, has brought forward a series of policy, regulatory and infrastructure challenges to Brisbane City Council. From an initial trial of 750 devices, Brisbane has expanded to a total of 2000 e-scooters and 800 e-bikes operated by two shared scheme operators in a competitive market. In addition, a vibrant retail industry for e-mobility devices has emerged. To guide the development of this industry and the regulatory response, Brisbane City Council (Council) has developed an e-mobility strategy, following an extensive community consultation process. This strategy is based on five key policy principles: safety, accessibility, mobility, agility and infrastructure. Council has implemented an ecosystem of shared e-scooter and e-bikes according to the objectives of the strategy and will continue to develop infrastructure and research to improve safety and confidence in this new mode of transport.

Empirical identifiability of Latent Class Models: Theoretical analysis and application to multiple heuristics modelling (72)

Felipe Gonzalez-Valdes *(Pontifica Universidad Católica de Chile),* ***B.G. Heydecker*** *(University College London) and* ***J. de D. Ortuzar*** *(Pontifica Universidad Católica de Chile)*

Abstract

Latent class (LC) discrete choice models have been found to exhibit identifiability problems. Theoretical identifiability addresses this issue in general, but no empirical identifiability analysis has been performed previously for these models. Here, we analyse

the identifiability of LC models and through this, establish that differences among classes are crucial in identification. We quantify the relationship between behavioural difference and empirical identifiability using maximum likelihood analysis, and proceed to show empirically that is informative in Bayesian estimation. Then, we simulate a common scenario of potential non-identifiability with multiple choice heuristics in a real transport mode choice context. Based on our simulation results, we show that Bayesian estimation procedures are more robust than likelihood maximisation whilst recovering our main results. We show a graphical diagnostic for identifiability and provide examples of model non-identifiability, weak identifiability and strong identifiability.

SESSION 1B: PUBLIC TRANSPORT

Australia's long distance passenger train and coach services: international comparisons [33]

Phil Potterton *(Economic Connections)*

Abstract

The paper compares Australia's long distance passenger train and coach services with those of 11 countries. Comparison countries have large land area and/or high income and no high speed rail network. Australia's long distance train routes are found to be slightly shorter than the comparison country median, whereas coach routes are substantially longer. While Australia's frequencies are below comparison country medians, high frequencies apply on particular routes, connecting more closely spaced population centres, as in two other 'low frequency' countries, Canada and USA. Australia's end to end route speeds exceed comparison country medians. Australia's train fares fall below the comparison country median, while coach fares slightly exceed it. Australia's service profile is consistent with a country situational profile of very large land area, very low population density, very high population concentration (understood as the proportion of a country's population living in its five largest cities) and high per capita income. However, many relationships between these four country indicators and service indicators are not statistically significant and historical and policy factors may also be important to outcomes. These include legacy rail gauge disconnects constraining route lengths and more recent Commonwealth and state upgrade initiatives improving route speeds. Australia's service frequency and fare profile profile are considered highly situational, the former linked to low population density and the latter to high GDP per capita. In high income nations, lower fares are a means to both differentiate and market service offerings, given competition from widely available fast air transport and convenient private vehicles. A learning for Australia, given a statistically significant association between route service frequency and route speed and drawing on Canada and USA comparisons, is the opportunity to explore putting in place frequent, faster and potentially well-patronised passenger rail services connecting Newcastle, Sydney, Wollongong and Canberra.

The impact of bus network reform on the resilience of Melbourne's public transport system [62]

Jan Scheurer *(RMIT University) and* ***Ian Woodcock*** *(Swinburne University of Technology)*

Abstract

Melbourne's Public Transport advocates have argued since the 1990s the most cost-effective and equitable way to achieve long-desired mode shifts to public transport in that city is reform of the metropolitan bus network. Melbourne's bus network is extensive, yet service delivery is notoriously ineffective, with slow, tortuous routes, infrequent, short service spans, timetables poorly aligned with trains and trams, creating generally poor network connectivity. Budgets for bus planning are constrained, meaning there has been scant work by government planners to re-imagine the network in the vein promoted by advocates. The Victorian Government's Bus Plan (DOT, 2021) acknowledges the issues with the network, but has little concrete in the way of targets or ways of achieving them. In this paper, we draw on network planning principles for multimodal public transport and some of the bus reform proposals of Melbourne's foremost advocates to create scenarios to increase the overall network coverage from its current level of 51% to 70% of residents and jobs by 2036. Using network scenarios derived

from government plans for rail and projections for population growth and distribution, we deploy the Spatial Network Analysis for Multimodal Urban Transport Systems (SNAMUTS) to assess the effects significant reform of bus service would have on these plans. We find that while significant increases in network accessibility could be achieved, there would also be significant stresses placed on the rail system, even with various upgrades and extensions envisaged, allied with a reduction in the role of Melbourne's trams. These results indicate that a focus on buses alone would be unlikely to deliver the kinds of benefits advocates have long sought and that serious attention must be given to the role of medium capacity systems to disperse demand within a more resilient network overall.

Neighbourhood typology and bus use: A simplified approach to predict bus demand [32]

Jeyashivraj Parthiban *(Wellington Shire Council),* ***Laura Aston*** *(Monash University) and* ***Graham Currie*** *(Monash University)*

Abstract

To compete with a growing number of alternative mobility options, bus operators and governments must be able to accurately anticipate bus demand and plan accordingly to encourage greater use in diverse areas. There is general understanding of the network design principles and built environment attributes that are more conducive to public transport use compared to private automobile use. However, relatively little is known about the importance of the built environment for bus use. Furthermore, there are some practical barriers to developing accurate and flexible bus demand prediction tools. This study addresses these two gaps by developing a bus demand prediction model based on neighbourhood typologies. The built environment attributes of bus stop catchments are combined, and clustered according to similar attributes. We compare the prediction performance of the model that predicts ridership using typologies, to a conventional multivariate model with individual built environment variables. The typological model explains slightly less variance but offers simpler interpretation and is more generalisable. Prediction models for individual neighbourhood typologies suggests that the relationships between the built environment and bus demand differ in parts of a city with different built environments. When the purpose of a model is to yield the most reliable prediction, the typological approach offers a simple way to predict demand while capturing spatial variation in the built environment. However, in situations where it is of interest to identify appropriate interventions for a particular site, it may be appropriate to collect and examine data for similar locations only.

Case Study: Standard deviation as a reliability 3 measure for public transport managed by headways [135]

Mathew Hounsell *(UTS)*

Abstract

This paper examines empirical data from public transport operations in Sydney, to assess if the mean end-to-end runtime, and its standard deviation, are useful measurements to monitor the reliability and efficiency of the public transport services delivered. As well as, whether these metrics should be collected and reported to the service authorisers to ensure that services maintain public support by achieving operational efficiency and minimise resource usage.

SESSION 1C: TRAFFIC MODELLING

Combining multiple traffic data sources to estimate Macroscopic Fundamental Diagram in large-scale 3 urban networks [36]

Elham Saffari *(University of Queensland),* ***Mehmet Yildirimoglu*** *(The University of Queensland) and* ***Mark Hickman*** *(University of Queensland).*

Extended Abstract

1.Introduction

Since the concept of the Macroscopic Fundamental Diagram (MDF) has been introduced by (Geroliminis and Daganzo, 2008), many studies have investigated the existence and characteristics of the MFD using empirical and simulation data. MFD is a powerful and efficient model for monitoring and managing large-scale urban networks. For instance, perimeter control (Ingole, Mariotte, & Leclercq, 2020), regional route guidance (Yildirimoglu, Sirmatel, & Geroliminis, 2018), demand management (Yildirimoglu & Ramezani, 2020) and control of city-scale ride-sourcing systems (Ramezani & Nourinejad, 2018). Nevertheless, estimating the MFD for large-scale networks faces important challenges; monitoring resources are often limited in such networks. Furthermore, common sensors that are used to collect traffic data (i.e., loop detectors and probe vehicles), have limitations of their own. For instance, loop detectors are fixed sensors and cannot provide accurate density measurements (Buisson and Ladier, 2009, Courbon and Leclercq, 2011). On the other hand, to estimate the MFD using probe vehicle data, the probe penetration rate must be known a priori. Given that the individual sensors cannot provide complete and accurate traffic measurements, combining the traffic data from multiple sources may improve the estimation of the MFD (Ambühl and Menendez, 2016, Beibei et al., 2016, Ji et al., 2018, Leclercq et al., 2014).

Our aim in this study is to develop a data fusion method that takes advantage of both (limited number of) loop detectors and probe vehicles, which may or may not be homogeneously distributed in the network. This study builds on the premise that full-scale traffic data (i.e., covering all links in the network), albeit approximate, is available for the network, which is produced as a result of our earlier work (Saffari et al., 2020). Very briefly, the previous study identifies a small number of critical links in the network where loop detectors should be installed, and produces an approximation of complete traffic variables (i.e., flow and density) for all links. In this study, in addition to loop detector measurements from the critical links, we assume that real-time probe vehicle data with an unknown penetration rate is available. These two data sets are the inputs to our fusion algorithm.

2. Methodology

In this section, we present the proposed methodology to combine real-time probe vehicle data, with an unknown probe penetration rate, and approximate full-scale traffic data (resulted from our earlier work). Applying the proposed fusion method, we can calculate link-flow and link-density for all the links in the network. Figure 1 presents the main steps of the proposed methodology. There are two main parts shown in the flowchart; 1) calculating the local penetration rates, and 2) applying the Bayesian fusion method. In the first part, we start with probe vehicle and loop detector observations on the critical links; this allows us to calculate the penetration rate for each critical link where a loop detector is installed. We then find the *k*-nearest critical links for each link in the network, and calculate the average penetration rate of these *k* links. This allows us to estimate a local penetration rate for each link, which may vary across the network. In the second part of the algorithm, we upscale probe vehicle observations, applying the estimated local penetration rates. This data is one of the inputs to the Bayesian fusion model. As shown in Figure 1, two traffic sources (i.e., approximate full-scale traffic data and upscaled probe vehicle measurements) are combined applying the proposed Bayesian data fusion model. The output of the model is fused link-flow and link-density values which we later use to estimate the MFD for the network.

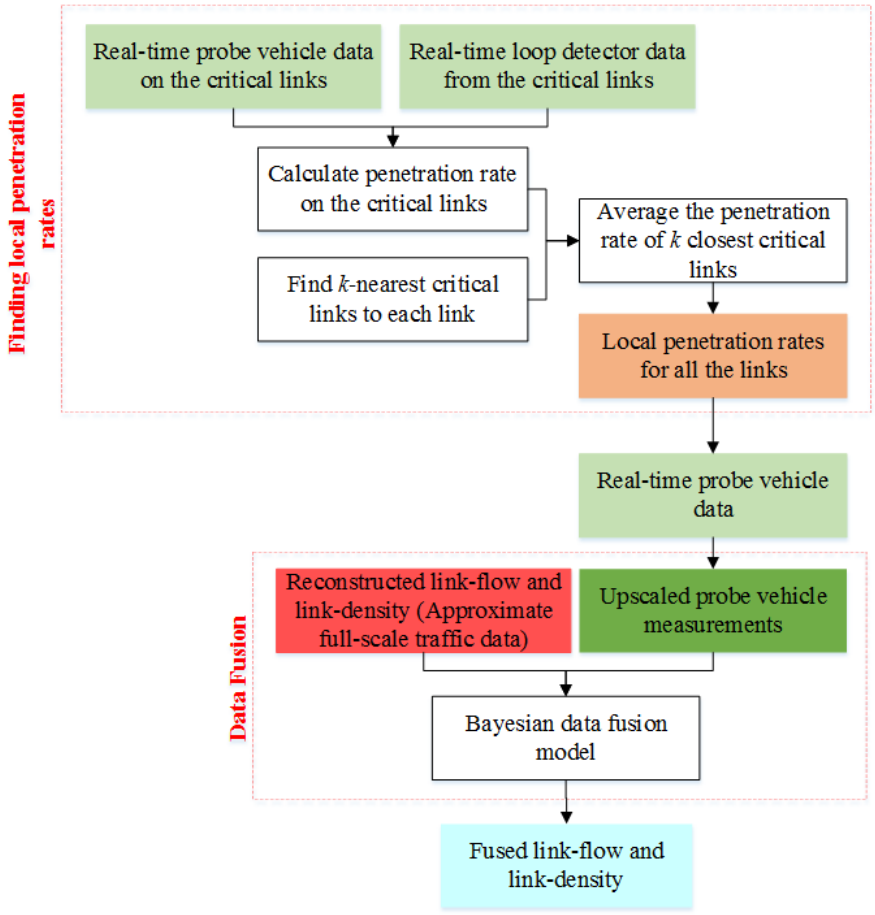

Figure 1: Flowchart of the proposed methodology

The data fusion method that we adopt in this study is based on Bayesian inference. As mentioned, in our problem, there are two sets of data, real-time probe vehicle and approximate full-scale traffic data, that we aim to combine by applying a Bayesian data fusion model. Let $q_a^{i,t}, q_p^{i,t}, k_a^{i,t}$ and $k_p^{i,t}$ denote approximate flow, flow based on probe vehicles, approximate density and density based on probe vehicles of link *i* in time of day *t*, respectively. n_a and n_p are the number of approximate traffic data observations and the number of probe vehicle observations, respectively. Let us assume M days of traffic measurements are available (i.e., M replications simulated in Aimsun). Thus, the number of observations on each link in each time of day interval can vary between zero and $M (0 \leq n_a, n_p \leq M)$. Based on Bayes theorem:

$$P\left(\mu_q^{i,t} \middle| q_a^{i,t}, q_p^{i,t}\right) = \frac{P(\mu_q^{i,t}, q_a^{i,t}, q_p^{i,t})}{P(q_a^{i,t}, q_p^{i,t})} \qquad P\left(\mu_k^{i,t} \middle| k_a^{i,t}, k_p^{i,t}\right) = \frac{P(\mu_k^{i,t}, k_a^{i,t}, k_p^{i,t})}{P(k_a^{i,t}, k_p^{i,t})} \tag{1}$$

where $\mu_q^{i,t}$ and $\mu_k^{i,t}$ denote the value of the fused flow and fused density of link *i* in time *t*, respectively. We omit *i* and *t* in the notation in the following equations for the sake of brevity.

Note that to avoid duplication and due to space limitation, we write the final equation only for calculating fused link-flow. The same formula will be applied for density to calculate the fused density values for the network links. Here, we assume that μ_q, q_a, q_pfollow normal distributions, $N(\mu_0, \sigma_0^2)$, $N(\mu_q, \sigma_a^2)$ and $N(\mu_q, \sigma_p^2)$, respectively. μ_0 and σ_0^2 denote the mean and variance of the prior distribution, respectively. We can find the mean of fused link-flow (μ_f) as:

$$\mu_f = \frac{1}{\frac{n_a}{{\sigma_a}^2} + \frac{n_p}{{\sigma_p}^2} + \frac{1}{{\sigma_0}^2}} \left(\frac{\sum_{r=1}^{n_a} q_a^r}{{\sigma_a}^2} + \frac{\sum_{s=1}^{n_p} q_p^s}{{\sigma_p}^2} + \frac{\mu_0}{{\sigma_0}^2} \right) \tag{2}$$

As mentioned earlier, we omit the link *i* and time *t* from the equations for simplification purposes. In other words, by applying Eq. 2, we calculate the fused flow value on link *i* in time interval *t*. Therefore, to find link flow values for all links in every time interval, Eq. 2 needs to be applied $N \times T$ times, where N is the total number of links in the network and T is the total number of time intervals. Once link-flow and link-density values are calculated, we can find the MFD parameters of network average flow $Q(t)$, and network average density, $K(t)$, using the following formulas:

$$Q(t) = \frac{\sum q_i(t) l_i}{\sum l_i} \qquad K(t) = \frac{\sum k_i(t)\, l_i}{\sum l_i} \tag{3}$$

where $q_i(t)$ and $k_i(t)$ are fused link-flow and density measurements from link *i* in time interval *t*, respectively. The length of each link is denoted by l_i.

3. Bayesian data fusion results

In this section, we investigate the performance of the proposed fusion algorithm based on a heterogeneous probe vehicle distribution and different subsets of critical links. The network of the study is a large-scale urban network of Eixample district in Barcelona, Spain, which is modelled in Aimsun, a well-known traffic simulation package. In order to generate probe vehicles and extract their trajectories, we use Aimsun API (Application Programming Interface) in a micro-simulation environment. The simulation period represents a 90-minute morning peak time. We consider seven replications of the explained micro-simulation model, representing '7 days' (i.e. the maximum number of observations is $\boldsymbol{M = 7}$). Note that the number of critical links shows the number of links with loop detectors placed on them. We explore subsets of 20, 40, 60 and 80 links that represent approximately 2%, 3%, 5% and 7% of the links, respectively. For each subset of critical links, we first apply *k*-NN to find the three nearest critical links for all the links in the network. Then, the penetration rate on each link is calculated by averaging the penetration rate of the three nearest critical links. Incorporating the penetration rates, we can upscale partial probe vehicle observations to complete traffic measurements (link-flow and link-density). Note that this is obviously an approximation of the complete traffic measurements. The upscaled real-time probe vehicle data set is one of the two inputs to the Bayesian fusion algorithm. The second input, as explained before, is the approximate full-scale traffic data. The next step is to apply the Bayesian data fusion method (Eq. 2) and combine the two aforementioned data sets and calculate the fused link-flow and link-density values.

The next step after finding the link level estimations is to use Eq. 3 to find the network average flow and network average density and estimate the MFDs using this fusion method. Figure 2 illustrates the estimated MFDs with respect to different subsets of critical links along with the ground-truth MFD which is calculated from the trajectories of all vehicles in the network. One expected observation is that having more critical links, which subsequently means having more loop detectors in the network, results in a better fit and less scatter. Having more loop detectors spread out in the network leads to better local penetration rate estimations which essentially improves the MFD estimations.

To evaluate our estimations, we compare the estimated network average flow and network average density with the ground-truth values by applying Eq. 4.

$$RMSE(Q) = \sqrt{\frac{\sum_{t=1}^{T}(\hat{Q}(t) - Q(t))^2}{T}} \qquad RMSE(K) = \sqrt{\frac{\sum_{t=1}^{T}(\hat{K}(t) - K(t))^2}{T}} \tag{4}$$

where $\hat{Q}(t)$ and $Q(t)$ stand for the ground-truth and estimated average network flow in time interval t, respectively; and $\hat{K}(t)$ and $K(t)$ are the ground-truth and estimated average network density in time interval t, respectively.

ground-truth MFD which is calculated from the trajectories of all vehicles in the network. One expected observation is that having more critical links, which subsequently means having more loop detectors in the network, results in a better fit and less scatter. Having more loop detectors spread out in the network leads to better local penetration rate estimations which essentially improves the MFD estimations.

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where $\hat{Q}(t)$ and $Q(t)$ stand for the ground-truth and estimated average network flow in time interval t, respectively; and $\hat{K}(t)$ and $K(t)$ are the ground-truth and estimated average network density in time interval t, respectively.

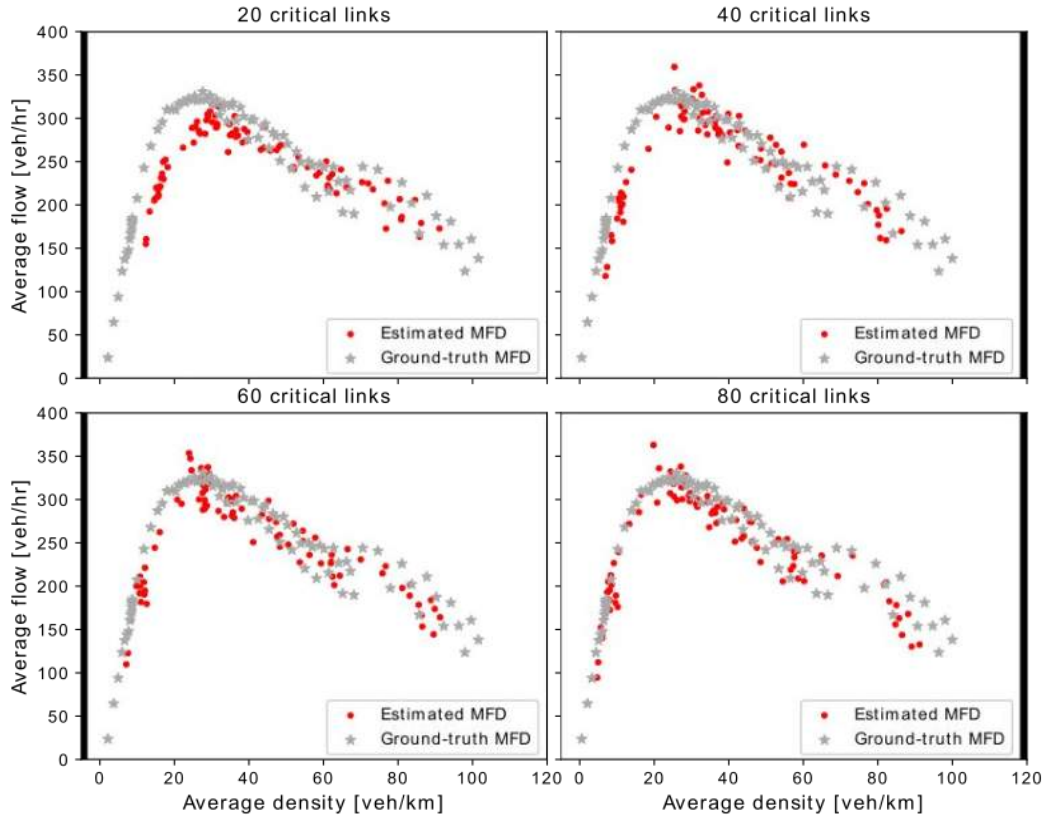

Figure 2: Estimated MFDs with respect to different subsets of critical links

The results of this calculation are presented in Table 1. This table also compares the estimation errors of the Bayesian fusion method and the baseline method which is applied in our earlier study. As we can see in Table 1, the Bayesian data fusion method improves the average flow and the average density estimations in most of the scenarios. Although we do not see a significant difference between RMSE(Q) from the fusion and the baseline method, we clearly observe a great improvement in all RMSE(K) values when applying the fusion model. The improvement in RMSE(K) ranges from 23% to 46%, whereas the improvement in RMSE(Q) is at most 7%. Note that, loop detector observations form the basis of the approximate full-scale traffic data. While the resulting flow estimations are fairly accurate and up to par with the fusion algorithm, the density estimations are significantly worse. These results can confirm the fact that loop detectors cannot provide accurate density measurements in congested signalized traffic sections, while they provide reasonably accurate flow measurements. Therefore, incorporating probe vehicle observations using the proposed fusion algorithm can significantly decrease the bias in loop detector density measurements and result in more accurate density estimations. Additionally, one possible reason that we do not see a considerable improvement in flow estimations, when incorporating probe vehicle observations, is that loop detector measurements do not significantly differ from the probe vehicle measurements. In other words, adding probe vehicle measurements to the loop detector measurements may not provide more information about the traffic state on the links.

Table 1: Estimation error with respect to different subsets of critical links

	Bayesian data fusion method		**Baseline method**		**Percentage improvement (%)**	
#Cririical links	RMSE(Q) [veh/km]	RMSE(K) [veh/km]	RMSE(Q) [veh/km]	RMSE(K) [veh/km]	RMSE(Q) [veh/km]	RMSE(K) [veh/km]
20	35.86	6.65	37.00	12.30	3	46
40	25.30	5.58	27.19	7.27	7	23
60	22.25	4.52	22.66	7.23	2	37
80	18.68	4.41	18.75	5.96	0	26

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Estimation of origin-destination flows in large scale traffic networks [41]

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Extended Abstract

1 Background and Aims

Reliable estimation of dynamic Origin- Destination (OD) flows in a traffic network is a crucial first step in developing an accurate traffic model, which can be later be used for the evaluation of various policies and management strategies. There has been a myriad of studies on the OD estimation problem. Most of the existing studies start from the premise that *a priori* OD information can be gathered through surveys and/or mathematical models, (*see* de Dios Ortúzar and Willumsen (2011) for details). However, such surveys may be outdated and limited, and mathematical models may not be advanced enough to tackle the inherent complexity of the underlying demand patterns. Therefore, *a priori* information on OD flows is often considered erroneous and does not adequately represent the existing demand patterns. OD flows can be improved and updated to develop posterior estimations based on link counts that can easily be collected by induction-based loop detectors, see e.g., (Bell, 1983; Fisk and Boyce, 1983; Zuylen and Willumsen, 1980; Cascetta et al., 1993). The core of the estimation problem is to find the share of trips passing through a link entering from any origin and headed towards any destination such that the sum of trips would match the observed link counts.

The basic theory of static OD flow estimation problem is formulated as an error minimization between observed and estimated values of link counts and *a priori* OD flows. A traffic assignment model which considers microscopic elements of the network such as link cost, path connectivity and path choice are used to estimate the resultant link counts from estimated OD flows. Therefore, the objective function of the minimization problem consists of two components; 1) the gap between estimated OD matrix resulted by OD estimation and *a priori* OD matrix, 2) the error between flows resulting from the estimated OD flow and observed link counts. The static OD estimation problem is extended to a dynamic (time-varying) scenario by discretizing the time horizon into finite number of time steps (j). Then, time-varying link counts are measured and OD flows are estimated for each time step. The complexity arises when dealing with these time-varying link counts as the demand of time step t_0 can cause link count at any time step $t \geq t_0$. Hence, the traffic assignment becomes a dynamic problem where dynamic route choice and dynamic link costs have to be incorporated, which makes the estimation problem a more complex and computationally expensive iterative process. The general formulation of OD flow estimation in dynamic case could be presented as;

$$\left(d^*_{[1]},.d^*_{[j]}\right) = argmin_{x_{[1]},.,x_{[j]}} \left\{ g_1\left(x_{[1]},.,x_{[j]},\widehat{d}_{[1]},.,\widehat{d}_{[j]}\right) + g_2(x_{[1]},.,x_{[j]},\widehat{F}_{[1]},.,\widehat{F}_{[j]}) \right\} \quad (1)$$

Note, $(g_1(.))$ is the measure of the distance between estimated OD flows $(x_{[1]}..x_{[j]})$ and the *a priori*OD flows $(\widehat{d}_{[1]},.,\widehat{d}_{[j]})$, and $(g_2(.))$ is the measure of the distance between the link counts resulting from the estimated OD flows $(x_{[1]}..x_{[j]})$ and observed link counts $(\widehat{F_{[1]}}...\widehat{F_{[j]}})$.

Many estimation methods were developed based on the above fundamental concept. The available techniques could be broadly divided into offline methods and online methods. The online methods target for real-time continuous time horizon OD flow estimation, while offline methods are focusing on the

finite time horizon estimations. We are interested in offline studies here. Most offline dynamic OD flow estimation methods develop a bi-level framework where the first level accounts for OD flow estimation and second level accounts for the dynamic traffic assignment (DTA) model. Marzano et al. (2008) observed that many existing methods face scalability issues when the number of OD pairs significantly larger than the number of links with link counts in a network, which is a common occurrence in medium to large scale networks. Further, the granularity of required information for microscopic and mesoscopic DTA models imposes a massive computational burden on the OD estimation problem, which challenges its practicality in the medium to large scale networks. In this study, we propose a hybrid OD flow estimation model that integrates a region-level OD estimation model with a traditional Traffic Analysis Zone (TAZ)-level (or centroid-level) OD estimation problem. This is a promising direction that has the potential to overcome the scalability issues and computational complexities faced by existing methods.

2 Problem Definition and Formulation

Here, we propose a hybrid OD flow estimation method by combining region-level and centroid-level OD estimation problems. We run the region-level OD estimation by partitioning a large-scale network into neighbourhoods with homogeneous traffic conditions. We expect that incorporating an aggregate level model to describe traffic dynamics will guide the centroid-level OD estimation and eliminate scalability issues and cut down computational complexities.

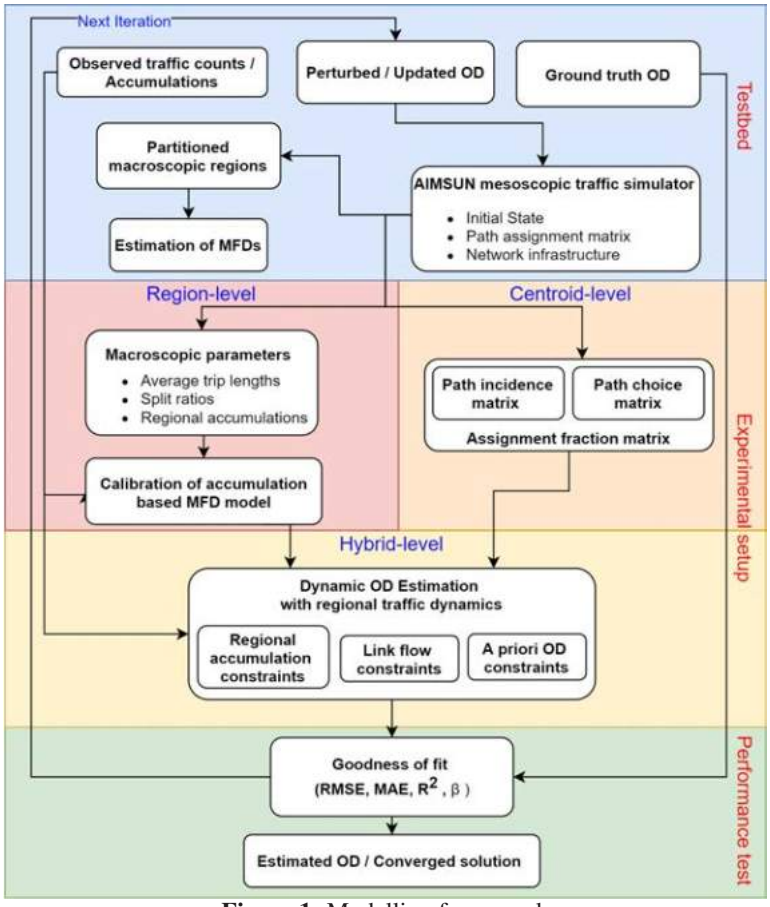

Figure 1: Modelling framework

Our method follows a three-stage modelling framework introduced by the benchmark study of Antoniou et al. (2016) on OD flow estimation. This modelling framework integrates all modelling components within three hierarchical layers such as test-bed setup, experiment setup and performance setup as shown in Figure

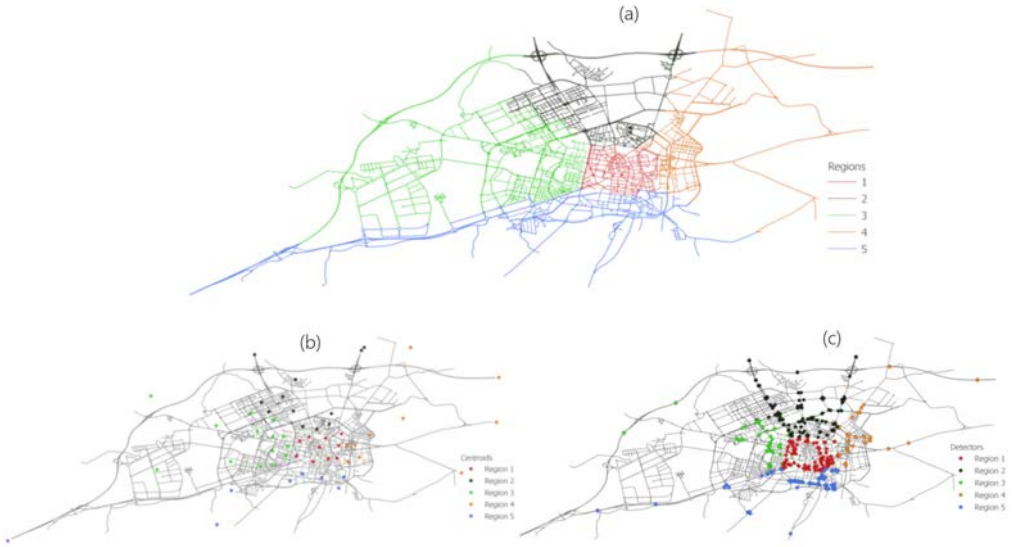

Figure 2: (a) - Proposed regions; (b) - centroid level ODs; (c) - traffic detectors

1. The test-bed layer establishes the preliminary components required for OD estimation such as observed link counts, ground truth OD, *a priori* OD, traffic simulation experiment, and assemble macroscopic components such as partitioning of the network and MFD estimations. We will be using the traffic network of Vitoria (Spain) to develop the methodology as it is suggested as a benchmark network for OD flow estimation, and has been used in the works of Antoniou et al. (2016); Djukic et al. (2011); Masip et al. (2018). The network has 57 centroids, 3249 OD pairs, 2884 nodes, 5799 links and expands to a modelled network of 600km. The *a priori* OD matrix will be obtained by perturbing the ground truth OD matrix with a uniformly distributed random noise (Antoniou et al., 2016).

The second layer of the modelling framework focus on developing the experimental setup. Here we have three allotments as region-level, centroid-level and hybrid OD estimation level. The centroid-level relates to the components in the (*or* conventional) OD estimation problem and the region-level relates to the collection of components (macroscopic parameters) that contribute to regional OD estimation based on regional traffic dynamics. Later, we present the hybrid OD estimation level where we discuss the formulation of OD estimation problem combining both region- and centroid-level components.

The regional components of the problem relies on the regional representation of traffic. On this regard, macroscopic fundamental diagram (MFD) presented by Geroliminis and Daganzo (2008) is adopted in this study. MFD builds an uni-modal, low-scatter and demand insensitive relationship between network flows and network densities for homogeneous traffic regions.

For the implementation of MFD modelling, the urban network is divided into five regions (neighbourhoods) with homogeneous traffic conditions, as shown in Figure 2-(a). MFDs for each region are estimated from the flow and density data collected from the loop detectors in the test-bed. The Figure 2-(b) shows the map of centroid level ODs and Figure 2-(c) shows the spread of traffic detectors in the network. The partitioning of the network into regions instigates a regional route choice phenomenon which occurs when there are two or more regional paths between two regions.Therefore, the traffic dynamics are handled by the multi-region accumulation-based model, which consider regional route choice. For more details on multi region MFD dynamics refer to Yildirimoglu et al. (2015).

Parallel to regional parameters, the centroid-level variables required for OD estimation are extracted. The path assignment required for conventional OD estimation problem will be extracted from the simulation environment (*see* Cascetta et al. (1993) for more details) . The benchmark platform followed in this study assumes that the OD routes and choice preferences generated by a dynamic user equilibrium will not deviate significantly over OD estimation.

The hybrid OD estimation problem is solved upon assembling region- and centroid-level components of the modeling framework. The optimization problem to estimate regional OD flows from link counts is formulated as a minimization problem as follows;

$$\underset{q_{ij}}{\text{minimize}} \quad \sum_{t=1:T}\left\{\sum_{l=1:L}\left(\frac{f_l^{\mathrm{o}}(t)-f_l^{\mathrm{c}}(t)}{f_l^{\mathrm{o}}(t)}\right)^2\right\} \tag{2a}$$

$$\text{subject to} \quad f_l^{\mathrm{c}}(t)=\sum_{\lambda=t-\eta:t}\sum_{i,j\in od} m_{l,ij}(\lambda)*q_{ij}(\lambda) \quad \forall\, l, \tag{2b}$$

$$Q_{IJ}(t)=\sum_{i\in I}\sum_{j\in J} q_{ij}(t) \quad \forall\,(I,J), \tag{2c}$$

$$N_I^{\mathrm{M}}(t+1)=g(Q_{IJ}(t),N_I^{\mathrm{M}}(t),L_{IH}(t),\Theta^I_{H,J}(t))) \quad \forall\,(I,t), \tag{2d}$$

$$N_I^{\mathrm{O}}(t)*\alpha_{lb}\le N_I^{\mathrm{M}}(t)\le N_I^{\mathrm{O}}(t)*\alpha_{ub} \quad \forall\,(I,t), \tag{2e}$$

$$q^{\mathrm{p}}_{i,j}(t)*\beta_{lb}\le q_{i,j}(t)\le q^{\mathrm{p}}_{i,j}(t)*\beta_{ub} \quad \forall\,(i,j) \tag{2f}$$

The objective function given in Equation (2a) targets to minimize the normalized error between the observed link counts (f_l^{o}) and calculated link counts (f_l^{c}) for all the traffic detectors $(1:\mathrm{L})$ and for all the time steps $(1:\mathrm{T})$. The decision variable of the objective function is q_{ij} where i,j represents the origin and destination respectively. In summary, Equation (2b) provides link counts ($f_l^{\mathrm{c}}(t)$) resulting from traffic assignment matrix ($m_{l,ij}$) and estimated OD $q_{i,j}$, which is the analytical approximation to traffic assignment at link level. Equation (2c) aggregates centroid-level ODs into region-level ODs Q_{IJ}. Here I,J represents origin and destination regions. Equation (2d) defines the MFD traffic dynamics where accumulation in the next time step $N_I^{\mathrm{M}}(t+1)$ is given by the demand ($Q_{I,J}(t)$), accumulation ($N_I^{\mathrm{M}}(t)$), average trip length ($L_{IH}(t)$), and split ratios ($\Theta^I_{H,J}(t)$) in current time step t. Equation (2e) defines the bounds for the regional accumulations given by MFD dynamics (N_I^{M}) with respect to the observed accumulations (N_I^{O}). This constraint helps to bound the solution space of $q_{i,j}$ such that centroid-level ODs are guided/shaped by the regional observations. Finally Equation (2f) generates constraints to the decision variable $q_{i,j}$ where the OD estimates are limited to a boundary defined by the *a priori* OD estimate $q^{\mathrm{p}}_{i,j}$. Note that $\alpha_{lb},\alpha_{ub},\beta_{lb},\beta_{ub}$ are non-negative constants. This complex optimization problem could be categorized as non-linear, non-convex optimization problem and we use iterative non-linear solvers (interior point solvers) to derive the optimal solution.

The third layer of our framework focus on goodness of fit test in estimates.While literature suggests a vast number of tests in dealing with the goodness of fit of OD flows and link counts, we will be using (1) Coefficient of determination (R^2) obtained by the regression of estimated ODs and ground truth ODs, (2) regression coefficient (β) of estimated ODs and ground truth ODs, (3) root mean squared error (RMSE) between observed link counts and estimated link counts, (4) mean absolute error (MAE) between observed link counts and estimated link counts. The preliminary results obtained by implementing the proposed OD estimation framework are successful. Figure 3 presents preliminary results of OD estimation for an uncongested scenario D7 which is a bechmarked scenario in Antoniou et al. (2016). The perturbed OD is underestimated by 15% on average with a random noise as shown in Figure 3-(a). We were able to obtain a significantly improved OD estimate after applying the hybrid OD estimation framework. Figure 3-(b) shows the agreement of estimated ODs with ground truth ODs where we observe $\beta = 0.99$ with a significantly high $R^2 = 0.95$. We see a very high match with high R^2 between simulated link counts with observed link counts as shown in Figure 3-(c). Further, Figure 3-(d) shows the reduction MAE in link counts over iterations, which demonstrate the capability of the hybrid OD estimation to derive the optimal solution within few iterations. In overall, the proposed experimental setup framework builds on two components; (i) guidance of regional OD estimation problem which relies on analytically tractable MFD modelling, and which therefore offers significant computational advantages, and (ii) traditional centroid-level OD estimation problem involving an additional constraints that links the two components. The motivation behind the proposed integrated structure is to produce high-level guidance towards the descent direction with the regional problem, which is relatively easy to solve, and thereby to call for fewer iterations in the overall OD estimation problem. We will further conduct experiments on several scenarios involving congested traffic conditions, and report the results in a future publication with further elaborations on theory.

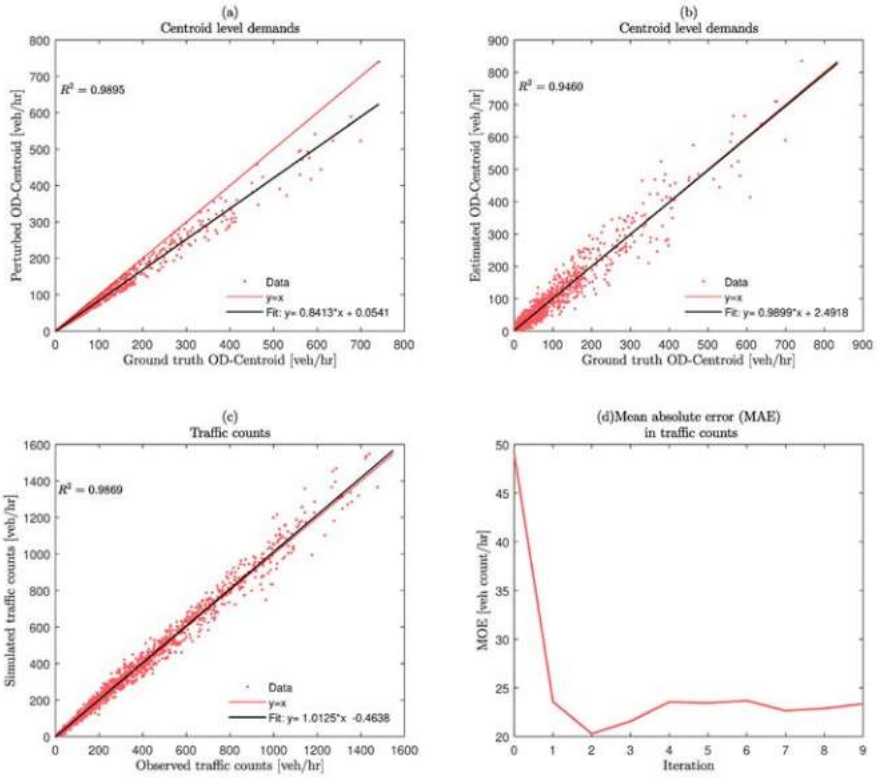

Figure 3: Preliminary results for uncongested demand scenario D7 (-15%)

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Network-wide traffic simulation with multi-agent imitation learning [61]

Jie Sun *(The University of Queensland) and* ***Jiwon Kim*** *(The University of Queensland).*

Extended Abstract

1. Introduction

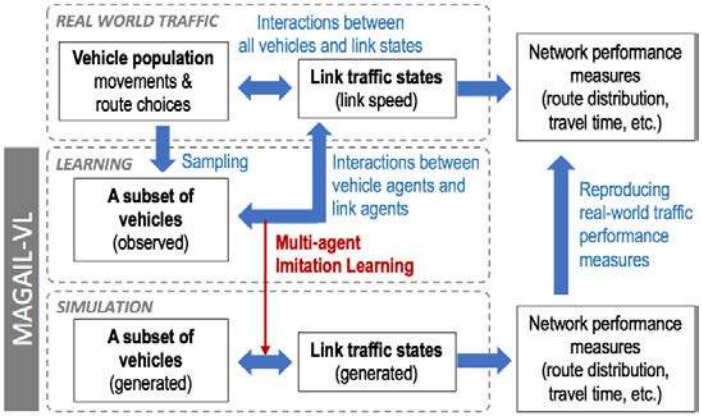
Due to the high complexity of traffic system, traffic simulation is an essential and efficient approach for the analysis and evaluation of the traffic system by modelling traffic flow dynamics and vehicle mobility in response to information and control actions, where network-wide traffic simulation could enable traffic engineers to predict the spatio-temporal movement patterns of vehicles and develop network traffic management strategies to alleviate traffic congestion (Mahmassani, 2001, Kim and Mahmassani, 2015). However, building conventional traffic simulation models is often time-consuming due to complex parameter estimation and calibration processes needed for a high-fidelity simulation model. Therefore, data-driven simulation has gained considerable attention in the recent decade with the increasing availability of high-resolution vehicle trajectory data and massive advances in deep learning models. While numerous data-driven microscopic traffic models have been proposed in the last decade, there is little effort made on network-wide mesoscopic/macroscopic traffic simulation based on trajectory data (Li et al., 2020). In this paper, we aim to develop a model that leverages both high-resolution trajectory data and deep learning to learn interactions between vehicles and a road network, which can provide the basis for enabling data-driven mesoscopic traffic simulation at the network-level.

While it is a relatively new concept in the transport research community, several relevant research topics have been studied, including the next location prediction problem, which aims to predict the next location in a trajectory of a user based on the previously visited locations (Sun and Kim, 2021), and vehicle trajectory generation problem, which aims to generate synthetic trajectory data using generative models to learn the mobility patterns (Ziebart et al., 2008, Choi et al., 2021). However, these studies model the movements of individual vehicles independently without considering the interactions between vehicles and between vehicles and a traffic network, which leads to limited applicability.

Our study aims to model the interactions of vehicles and the road network by employing a *multi-agent imitation learning* (MAIL) framework, which learns behaviours of a multi-agent system based on demonstrations of a set of experts interacting with each other. By considering observed traffic and trajectory data 'expert demonstrations', the imitation learning (IL) approach can train a multi-agent model to generate trajectories and traffic effects that mimic the 'demonstrated' real-world behaviours. A naïve approach to building such a multi-agent model might be to model the whole vehicle population in the network as individual vehicle agents, but it is computationally expensive. Currently, the largest number of agents modelled in the literature of multi-agent imitation learning is only 100 (Bhattacharyya et al., 2018). As such, we propose the idea of learning the interactions between *a subset of vehicles* and *road link traffic states*, instead of attempting to model the interactions among all vehicles, by developing the **M**ulti-**A**gent **G**enerative **A**dversary **I**mitation **L**earning model with **V**ehicle and **L**ink agents (MAGAIL-VL). Figure 1 shows our model framework. In a real-world traffic network, vehicles' route choice actions determine the traffic states across the links (e.g., link speed) and the link traffic states, in turn, affect vehicles' route choices. The consequences of

such interactions are captured through various network performance measures such as route distribution and travel times. Unlike traditional mesoscopic traffic simulation models, which typically use dynamic traffic assignment (DTA) to model route choice behaviour and vehicle-road link interactions, our MAGAIL-VL model attempts to learn the vehicle-road interaction patterns directly from data by applying MAIL to a subset of vehicle trajectory data to train vehicle agents and all link traffic data to train link agents. This learned interaction is then transferred to a simulation environment, where a new subset of vehicles and link states can be generated and simulated to produce the network performance measures that mimic the network performance under the whole population. The goal is to predict the population network performance measures by modelling only a subset of vehicles and their interactions with the underlying road network.

Figure 1: Schematic diagram of the concept of this study



2. Methodology

Imitation learning (IL) is a powerful alternative to Reinforcement Learning (RL) for learning sequential decision-making policies when manually defining *reward* functions is challenging. It attempts to recover an optimised reward function that could rationalise the expert demonstrations observed in the real data (Ho and Ermon, 2016). MAIL is an extension of IL which could learn multiple parametrized policies that imitate the behaviour of multiple experts from demonstrations of a set of experts interacting with each other in the same environment. MAGAIL is a specific algorithm of MAIL which applies generative adversarial networks (GAN) in the MAIL and includes a generator and a discriminator (Song et al., 2018). The generator controls the policies of all the agents, and the discriminator is a classifier trained to distinguish agent's behaviour from that of the corresponding expert.

2.1. Problem formulation

In MAGAIL-VL, a traffic network is formulated as a multi-agent system consisting of two groups of homogenous agents—links and (a subset of) vehicles—and their interactions are modelled using a Markov game containing N agents including n link agents $(1, \dots, i, \dots, n)$ and m vehicle agents $(n+1, \dots, j, \dots, n+m = N)$. The state of link agent i is: $s_i = \{i, linkstate\}$, where $linkstate \in [1, \dots, k]$ indicates the congestion level of link i (speed range). The action space for link agents represents possible changes in link congestion level: $\{A_i\}_{i=1}^{n} = A_l = \{+1, \dots, +(k-1), -1, \dots, -(k-1)\}$, which allows the state to vary between $\{i, 1\}, \dots, \{i, k\}$. The state of vehicle agent j is: $s_j = \{k, linkstate\}$, where k denotes the link that vehicle j is travelling on, and $linkstate$ is the congestion level of link k. The action space for vehicle agents represents possible movement of a vehicle on a link: $\{A_j\}_{j=n+1}^{N} = A_v = \{$ *Transfer to the leftmost link, the second leftmost link,…, the rightmost link, Stay on the same link, Enter the network, Exist the network, Stay outside the network before entering, Stay outside after*

existing}, where a vehicle can choose to move to a downstream link or stay at the current link at each time step. The function $\eta \in P(s)$ specifies the distribution of the initial states. Given that the agents are in state $\mathbf{s}^t$ at time t and agents take actions $(a_1, \dots, a_N)$, the state changes to $\mathbf{s}^{t+1}$ with probability $P(\mathbf{s}^{t+1}|\mathbf{s}^t, a_1, \dots, a_N)$. Each agent achieves its objective by selecting actions through a stochastic policy $\pi_i: S \to P(A_i)$. While different policies are to be specified for distinct agents in the original MAGAIL, to enables the model to incorporate a much larger number of agents in one multi-agent system, we define the same policy for link agents as π_l and the same policy for vehicle agents as π_v. The reward function of each agent is $r_i: S \times A_l^n \times A_v^m \to \mathbb{R}$. The reward function of agents: $\{r_i\}_{i=1}^n = r_l, \{r_j\}_{j=n+1}^N = r_v$. The goal of each agent is to maximise the total expected return $R_i = \sum_{t=0}^{\infty} \gamma^t r_{i,t}$, where γ is discount factor. The joint policy is defined as $\boldsymbol{\pi}(\boldsymbol{a}|\boldsymbol{s}) = \prod_{i=1}^n \pi_i(a_i|s_i) \prod_{j=n+1}^N \pi_j(a_j|s_i)$. The objective of this Markov game problem is to find the optimal reward functions and policies from the expert trajectories (vehicle trajectory and link state data) that could explain the expert behaviour (vehicle mobility pattern).

2.2. MAGAIL-VL

Using the GAN framework, MAGAIL-VL consists of the generator (G) to make realistic vehicle trajectories and link state changes based on the policies and the adversarial discriminator (D) to give reward feedback to the vehicle trajectories and link states generated by the generator until convergence. The policy and discriminator are both neural networks and the training process of MAGAIL-VL is as follows: With the initiated Markov game, we first generate vehicle trajectories and link states by rolling out the policies π_l and π_v for specific time steps. After sampling state-action pairs χ_E and χ_π from both expert trajectories and generated trajectories, respectively, the discriminator parameter could be updated by optimising the objective $\min \max \mathbb{E}_{\chi_\pi}\left[\sum_{i=1}^N \log\left(D_{\omega_i}(s,a_i)\right)\right] + \mathbb{E}_{\chi_E}\left[\sum_{i=1}^N \log\left(1 - D_{\omega_i}(s,a_i)\right)\right]$, where ω_i is the parameter set of the discriminator. Implicitly, D_{ω_i} plays the role of a reward function for the generator. Then the policy parameters are updated through reinforcement learning where a state-of-the-art natural policy gradient algorithm Multi-agent Actor-Critic with Kronecker-factors (Song et al., 2018) is used. The learned policies and reward functions are then obtained with repetition of this process. With the well-trained models, we can then generate vehicle trajectories and link states to simulate the network operation.

2.3. Baseline models

In addition to the proposed MAGAIL-VL model, we have developed several models for comparison. The first baseline model is MAGAIL-V which only considers the vehicle agents, while other configurations are similar to the MAGAIL-VL model. Additionally, we develop a single agent model base on GAIL (Ho and Ermon, 2016), while vehicle trajectories are generated sequentially by applying the model for specific times and no interaction exists between the vehicles. Moreover, we adopt the long short-term memory (LSTM) model and LSTM combined with self-attention mechanism (LSTM-attention) model as baseline models since they were demonstrated as efficient models in learning long-range location relations and predicting vehicle trajectories (Sun and Kim, 2021).

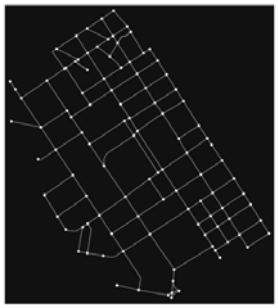
2.4. Evaluation measures

To evaluate the performance of proposed models, we employ *BLEU* (bilingual evaluation understudy) score to evaluate the accuracy of individual generated trajectories, where *BLEU-N* measures how consistent a model can generate *N* consecutive locations with an observed trajectory. For the network-level performance measures, we use the Jensen-Shannon distance of route probability distribution between generated and real trajectories, the mean absolute percentage error (MAPE) of average link travel times, and the mean absolute error (MAE) of link traffic states between the simulated network and the real network.

3. Data preparation

The data used in this study are extracted from the open traffic drone data collected in Athens, Greece through 20 datasets covering a few hours over four days (Barmpounakis and Geroliminis, 2020). We extract the data for a moderate-scale network (including 143 road links) as shown in Figure 2 with the time step of 10s. After map-matching vehicles' coordinate data using hidden Markov model (Meert and Verbeke, 2018), we obtained 600-800 vehicle trajectories for each dataset as population trajectories, where each trajectory dataset covers 80 time steps (800s). We then randomly sample 200 vehicle trajectories from each of the 20 datasets, resulting in 4000 vehicle trajectories in total. A sample of 200 vehicles per dataset represents approximately 25-33% of the population. The link states are identified according to the average speeds of vehicles on that link. We cluster five and three link states using K-means clustering method, for MAGAIL-VL-5 and MAGAIL-VL-3 model, respectively. In this study, we use the trajectories in first three days (15 datasets, training dataset) to train the models and test the models on the training dataset and further validate the model on the trajectories in the last day (5 datasets, validation dataset).

Figure 2: The study network



4. Results and Discussion

Based on the proposed models, we generated the trajectories of new 200 vehicles and link states for a simulation period of 800s, which corresponds to the observation period of the actual trajectory datasets. Note that the departure times and locations of vehicles are given as per the observed trajectories, and vehicles then travel to other locations based on the generator policy of models. We assess the model performance by comparing the consistency of generated dataset with the observed dataset with the proposed evaluation measures. The evaluation results for the training dataset and the validation dataset are provided in Figure 3 and Figure 4, respectively. The MAGAIL models perform better than other models in terms of the vehicle trajectory accuracy indicated by higher *BLEU* scores, demonstrating the effectiveness of capturing agent interactions in learning realistic vehicle movements. For the network-wide performance measures, the proposed MAGAIL-VL models overall outperforms other models, especially in link travel time measure. The performance of MAGAIL-V is quite poor in link travel time measure, suggesting the importance of considering both vehicle and link agents, rather than vehicle agents only. The traffic state measure results are reported only for the two MAGAIL-VL models with link agents that produce link state changes. The models with five traffic states and three traffic states have a MAE around 1 and 0.5, respectively, which indicates that the predicted link congestion level is on average half-state different from the actual link congestion level. Overall, MAGAIL-VL provides the most satisfactory performance in both trajectory-level and network-wide measures. This study demonstrates the possibility of modelling the network-wide traffic state evolution by learning the interaction between only a subset of vehicles and the surrounding link congestion levels. This finding provides an important first step towards enabling a fully data-driven traffic simulation model for a large-scale network in a more effective and efficient manner.

Figure 3: Evaluation results for the training dataset

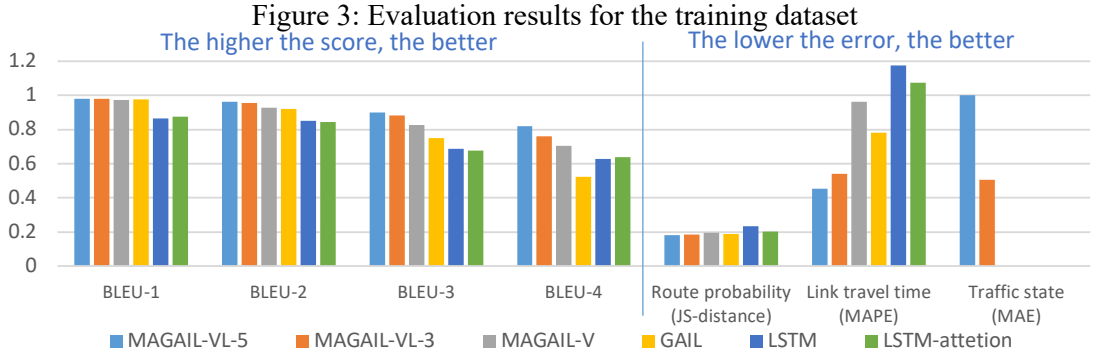
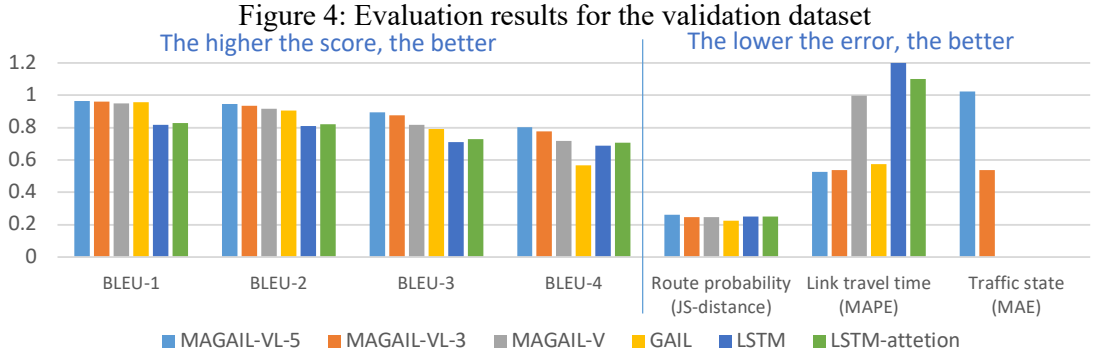


Figure 4: Evaluation results for the validation dataset



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Traffic forecasting in a freeway corridor using Seasonal ARIMA Model [117]

Mahmuda Akhtar *(RMIT University),* ***Sara Moridpour*** *(RMIT University) and* ***Majidreza Nazem*** *(RMIT University)*

Abstract

Traffic congestion is becoming a critical problem in everyday life. The crucial need for a sustainable traffic forecasting method is becoming acute with time. This study develops an Auto Regressive Integrated Moving Average (ARIMA) model to estimate the short-term traffic forecasting in uninterrupted traffic flow using stationary sensor data. The transportation authorities can use the developed model to predict and avoid any traffic congestion incident by planning. In this paper, a major freeway section of Melbourne, Australia, is used as a case study. The model uses traffic volume data of 15-minutes intervals of 63 workdays from the Eastern freeway westbound corridor of Melbourne, Australia. Among 63 days, almost 50 days of data were used as the model's input variable, and the rest 13 days data was used to validate the developed model. The model's Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and Mean Absolute Percentage Error (MAPE) values were as low as 0.28, 0.21, and 8.38%, respectively. The model was validated against the seasonal naïve model and found more effective than seasonal naïve.

SESSION 1D: ECONOMICS

Assessing toll road demand in New Zealand [122]

Neil Douglas *(Douglas Economics),* ***Don Wignall*** *(Transport Futures) and* ***Tony Brennand*** *(NZTA).*

Abstract

If the Auckland Harbour Bridge toll had been in place in 2021 the car toll would have been approaching $6 but the toll was removed in 1984. However, there are three toll roads operating in New Zealand in 2021 which is what most of this paper is about. There are two in Tauranga and one north of Auckland. The tolls are low at only half what the Auckland Harbour Bridge would probably have been. The tolls are also low when benchmarked against Australian and some other overseas examples. After assessing the low level of toll, the paper moves on to using the New Zealand Transport Agency electronic toll registration database to assess vehicle and revenue ramp-up, frequency of toll road use, demand and revenue by class of vehicle and the geographic spread of registered users. An innovative gravity model is fitted to the registration data and used to forecast demand for a major new 27 kilometre highway out of Wellington under construction at the time of writing. The gravity model is compared with a more conventional approach of using a road traffic assignment model with toll included as a time penalty. The gravity model forecast annual revenue of $9 million which was three-quarters of the road traffic assignment model. Neither of the two forecasts are high however with revenue amounting to only 3% of the $300 million annual revenue of the 'hypothetical' Auckland Harbour Bridge toll. The low revenue forecast reflects the prevailing low toll environment in New Zealand, low values of travel time and a likely lack of competitiveness of the road in question.

The development and application of a land use, transport and economy interaction model [71]

Henry Le *(AECOM),* ***Finn Gurry*** *(AECOM),* ***Michael Byrne*** *(ARUP),* ***Neville Wood*** *(Department of Transport Victoria) and* ***James Lennox*** *(Victoria University, Australia).*

Abstract

Governments around the world need to assess the benefits of transport projects to prioritize investments. It is imperative for governments to have tools that can estimate the true benefits and impacts of investments in significant transport projects. Traditionally, the benefits of a transport project have been estimated by using a transport model, assuming fixed land use for the base and project case in the future. However, this approach cannot measure the impact of land use changes as residents and businesses relocate to take advantage of lower travel and/or freight costs resulting from implementation of the project. Consequently, the benefits of the project may be under- or over-estimated, depending

on its position within the transport network and how it reshapes land use patterns in the future. In order to overcome this drawback in existing models, this presentation discusses the development of a land use, transport and economy interaction model for the state of Victoria, Australia (VLUTI), by integrating the Victorian Integrated Transport Model with a Spatial Computable General Equilibrium model, which simulates land use and economic interactions across the whole state, and considers the costs of commuting travel, consumption travel, business travel and freight transport. The presentation will discuss a hypothetical application of the VLUTI by looking at differences in the conventional transport benefit under both static and dynamic land use scenarios. In the static method, the land use in the project case is unchanged from the base case. In the dynamic case, the land use in the project case is endogenously adjusted within VLUTI. It will also present a method to correct, in the dynamic case, the benefits as estimated by the rule of a half, which usually assumes static land use.

Optimal toll charges for multi-class vehicles in City Logistics [28]

Loshaka Perera *(University of Moratuwa),* ***Russell Thompson*** *(University of Melbourne) and* ***Wenyan Wu*** *(University of Melbourne)*

Abstract

Many expressway facilities around the world are built using public-private partnerships (PPP), which is a popular method to finance urban roads. Various toll charges are imposed over multi-class vehicles by road investors in association with the government to recover and produce a return on their investment. High toll charges on heavy vehicles can lead to heavy vehicles using alternate roads to reduce freight costs. The resulting increase in the use of substandard roads by heavy vehicles, which has led to higher environmental and social costs, i.e. the externalities. Presently, externalities are paid by the general public (indirectly) and this has become a major problem in many cities, including the Melbourne. As a result of increasing externalities, there is a growing demand for road users to pay for these externalities, known as cross subsidization of transport externalities. In this study, we propose an innovative approach to reduce the total cost, including economic, social and environmental costs, of goods movement within cities via charging optimal tolls for expressway facilities. This approach looks at the optimization of multi-objectives from multi-stakeholders under a bi-level modelling framework. The non-dominated sorting genetic algorithm II (NSGA II) was used to find the optimal set of solutions, i.e. the Pareto-front, which shows the trade-offs between different objectives. The benefits of this approach are demonstrated using a hypothetical network with static demand conditions. Solutions with different economic, social and environmental cost combinations were obtained considering different stakeholders' preferences. This study provides insights into how sensitive the toll price setting can be and how a win-win solution can be achieved.

DEBATE: THAT MICROMOBILITY IS GOOD FOR CITIES

The rise of small electric bikes, scooters, and skateboards has started transforming urban travel in Australian cities. Queensland now has public e-scooter sharing systems in cities as diverse as Townsville, Bundaberg, Hervey Bay and Brisbane. But is this 'micromobility' revolution good for cities?

Participants:

Dr Abraham Leung, Griffith University
Brendan O'Keeffe, Brisbane City Council

SESSION 2A: DEMAND MODELLING

A new employment market segmentation-'purple collar' for transport models, a case study in South-East Queensland, Australia [127]

Yiping Yan *(Griffith University),* ***Matthew Burke*** *(Cities Research Institute, Griffith University) and* ***Abraham Leung*** *(Cities Research Institute, Griffith University).*

Abstract

The conventional blue/white collar duality in market segmentation dominated travel demand modelling since the 1960s. Many city-region transport models

have struggled to keep up with what have been systemic changes in labour markets since that time, especially the growing participation of women. Our aims were to help the Queensland Government development a new commuter classification structure for the BSTM by exploring the latest SEQTS data. The paper deliberately takes an inductive approach to explore household travel survey data for South-East Queensland, Australia, a region with high rates of female participation in the labor force. An inductive approach allowed us to identify from within the data itself what might be improved groupings of commuters. Using cluster analysis, commuter types are grouped by a key set of occupational, industry, gender and other socio-demographic variables (i.e., age, household size, household vehicle number, household bike number, skill score). Through travel behavior comparison analysis, the results reveal there are two very distinct types of female-dominated commuters and male-dominated commuters that cannot be easily combined into one single grouping. Instead, these two female-dominated types, which we call 'purple-collar' and 'aqua-collar' workers, have separate travel behavior characteristics. Among the four types of workers, 'blue collar' workers are making longer distances trips to workplace and show the highest level of dependence on private motor vehicles; 'white collar' have the lowest car dependence and relatively short trip distances. Notably, in general, blue- and white-collar workers tend to have longer median trip distances than both purple- and aqua-collar workers. This is in line with previous research on Australian households showing that women often take work closer to home to be closer to schooling and childcare.

Do digital natives telework more than digital immigrants? [60]

Yu-Tong Cheng *(The University of Melbourne),* ***Patrícia Lavieri*** *(The University of Melbourne) and* ***Sebastian Astroza*** *(1. Universidad de Concepción; 2. Instituto Sistemas Complejos de Ingeniería (ISCI)).*

Abstract

Information and communication technologies (ICTs) have significantly evolved in the past decades and now take part in multiple dimensions of people's lives. This rapid technological development occasioned generational differences in terms of individual exposure and interaction with ICTs. Individuals born before 1980 are often called digital immigrants, while those born after 1980 are digital natives. Because digital natives have a closer relationship with ICTs, their opportunities and willingness to conduct ICT-based activities are expected to be higher than those of older generations. In this context, this paper examines whether digital natives are more likely to engage in teleworking than digital immigrants. We use panel data from Australia to conduct an exploratory analysis and estimate a bivariate model of the choice to work from home and the proportion of time spent working at home. Overall, occupation type and age, which can be considered a proxy to career stage, seem to be much stronger predictors of teleworking engagement than generational cohorts. Additionally, after controlling for multiple covariates, we conclude that digital natives, represented by individuals born between 1981 and 1985 are actually less likely to work from home than digital immigrants.

The role of culture and evolving perceptions in mobility choices amongst immigrants in Australia [25]

Rahman Shafi *(Monash University),* ***Alexa Delbosc*** *(Monash University) and* ***Geoffrey Rose*** *(Monash University)*

Abstract

Australian has a rapidly growing population fuelled by immigration. However, to date there has been very limited research on immigrants' travel patterns. South Asians are the largest and fastest growing immigrant subpopulation in Australia, and they are known to be less car dependant and rely more on public transport than native-born Australians; however, they assimilate over the span of a few years and eventually rely more on cars. This study explores this assimilation using a qualitative approach. New insights into cultural influences on travel patterns are identified, along with a new concept coined as the "honeymoon period".

The influence of weather on bus ridership for different passenger types in Canberra, Australia [92]

April Alcock *(School of Civil Engineering, University of Sydney),* ***Milad Ghasri*** *(School of Engineering and IT; UNSW Canberra at ADFA),* ***Nathan Urban*** *(Transport Canberra and City Services Directorate, ACT Government) and* ***Emily Moylan*** *(School of Civil Engineering, University of Sydney).*

Abstract

The ability of transportation agencies to respond to short-term fluctuations in travel demand is central to the provision of resilient and reliable mobility. Weather may induce these intra-day and day-to-day variations in demand through its composite influence on travel behaviour, activity behaviour and socio-psychological attributes. As such, weather is likely to impact socio-demographic groups within the ridership differently. This abstract looks at weather and ridership patterns on buses in the ACT in 2017 and 2018. Attributes of the travellers are based on their MyWay card type. Regression models show statistically significant relationships between weather and ridership, and those relationships differ by time of day and card type. Lagged variables are used to capture the effect of memory on sensitivity to weather conditions. The conclusion is that the socio-demographic groups represented by the various card types have different ridership responses to weather as expected. The 'captivity' to transit implied in these behaviours suggests that, for some groups, low ridership in weather indicates that more rather than fewer transit services might be required to maintain mobility.

SESSION 2B: FREIGHT

Australian road freight – Measuring and modelling [23]

David Gargett *(BITRE)*

Abstract

This paper presents a methodology for removing 'survey noise' from a time series of Survey of Motor Vehicle Use (SMVU) statistics on road freight in Australia. Once this has been done, a model is fitted to the adjusted data, allowing forecasts for future growth in road freight. The model also allows the examination of the effects of COVID on road freight, using the ABS 4-month breakdowns of 2017-18 and 2019-20.

Freight modelling in Australia in 2021 – A data availability perspective [88]

Caitlin McHugh *(Veitch Lister Consulting),* ***Pedro Camargo*** *(Outer Loop Consulting) and* ***Tom van Vuren*** *(Veitch Lister Consulting)*

Abstract

Despite the fact that freight and commercial vehicle movements are expected to grow at a fast rate in the next couple of decades in Australia, the existing freight modelling components for the majority of Australian cities is lagging substantially behind their personal travel counterparts and no statewide or nationwide models are openly available for planning of infrastructure and scenario analysis. In this paper, we analyse the freight data availability and discuss their suitability for the development of freight models in Australia. A comparison was also made against data and modelling advancements in both the USA and Europe.

Predicting freight demand for planning loading docks [50]

Khalid Aljohani *(The University of Melbourne),* ***Michael Stokoe*** *(Transport for NSW),* ***Nikolai Tinsley*** *(Transport for NSW) and* ***Russell Thompson*** *(The University of Melbourne)*

Abstract

With a greater focus on placemaking in urban centres, the provision of off-street loading docks can make a significant contribution to traffic management in urban centres This paper describes the development of a Decision Support System (DSS) to forecast the generated freight task of a development and determine the optimal provision of on-site loading docks in new major developments. A predictive model using regression techniques with cluster membership to estimate parking demand and vehicle movements by freight and service vehicles in loading docks is described.The model processes various parking surveys collected by Transport for NSW (TfNSW) from buildings in Sydney of different land uses across a three-weekday period. The output of the model is presented in two interactive templates. The first one is the 'Optimisation Solver' template that determines the recommended dock configuration for the building under consideration by calculating the optimal number of parking spaces. The goal is to minimise the parking area while keeping the dock's effectiveness (ability to accommodate incoming vehicle demand) to a user configurable service level. The second template is the 'Dashboard' which displays valuable insights about the parking demand, vehicle movements and utilisation of the dock. The Dashboard is an interactive and transferrable template that various stakeholders could use in different locations to input the parameters and generate the results and outputs. The overall model development approach ensures a mathematically robust process to ensure the outputs' validity based on the observed datasets. The model has several applications and provides various stakeholders including transport authorities, city planners and property developers, with a user-friendly tool to assess the requirements in advance during the planning and approval process of new developments. Model applications include space proofing, supporting planning applications, enhancing the overall logistics delivery and service operations of the development, and streamlining the traffic flows in and around the development, making it more attractive to the future tenants and end-users.

Planning for urban freight through loading dock provision in new developments [51]

Michael Stokoe *(Transport for NSW)*

Abstract

Freight and servicing movements entering a city need a place to park to service customers. This will invariably occur on the street in parking spots or in off-street facilities that are part of the building to be serviced. In light of declining on-street loading zone spaces, this paper explores the provision of off-street loading docks to support freight task activity in major urban centres. While it may not be realised, provisions to adequately accommodate a city's generated freight task is highly important to urban planner's objectives. Many cities are pursuing objectives to reduce car-centric planning approaches and become more attractive people-centric places with large amounts of pedestrianised streets and space. While there are other alternatives, trucks are likely to continue to be the efficient mainstay of the freight task going forward. As a non-discretionary transport task, freight vehicles will continue to enter cities. If good off-street loading dock facilities are not provided, vehicles will seek out legitimate or illegal on-street parking, and urban planner's place making objectives are likely to be compromised. The paper focuses on Sydney but draws on comparisons primarily to the City of London. The paper first considers the planning approaches that govern the provision of loading docks. It then considers various stakeholder perspectives towards loading dock provision and use. Finally, it discusses approaches of how a transport authority may seek better outcomes. The author and his team are directly involved as urban freight subject matter experts in urban transport planning and the assessment of loading dock activity and in Sydney, Australia.

SESSION 2C: BIG DATA

Data-driven traffic incident prediction with hybrid graph-based neural network [58]

Thanh Tran *(The University of Queensland),* ***Dan He*** *(The University of Queensland),* ***Jiwon Kim*** *(The University of Queensland)* ***and Mark Hickman*** *(The University of Queensland)*

Extended Abstract

1. Introduction

Traffic incident management plays an essential role in Intelligent Transportation Systems since incidents such as vehicle crashes usually cause severe congestion on traffic networks and even human fatalities. Accurate incident prediction that estimates the probability of whether a traffic incident will happen or not in a specific region ahead of time would be helpful to provide road safety guidance and improve traffic conditions by preventing congestion. However, it is challenging to achieve acceptable prediction performance since traffic incidents could be caused by multiples factors such as traffic condition, weather condition, road structures, and driver behaviours, which are often difficult to capture in a given prediction model due to a lack of data or a challenge in fusing heterogeneous data sources. Recently, with the ubiquitous availability of location-aware sensor technologies such as GPS devices, more diverse sets of traffic data have become available in addition to traditional loop detector data. The increase in diverse traffic data can facilitate traffic prediction solutions, but a new challenge arises in the fusion of data from multiple sources with different granularity and penetration. As such, data-driven approaches that can flexibly leverage diverse data sources are highly desirable. In the literature, many classical machine learning methods are applied in traffic incident prediction such as K-nearest neighbor (Lv, Tang, and Zhao 2009) and Bayesian Network (Hossain and Muromachi 2012), which make predictions based on manually generated features extracted from traffic incident data. The generalisation ability of these algorithms is relatively low since important factors causing incidents including traffic flow data, road networks, and meteorological data are not considered. Recently, deep learning techniques have been applied to predict traffic incidents integrating more data sources. Particularly, Ren et al. (2018) developed a model base on Long Short-Term Memory (LSTM) to predict traffic incident risk by learning periodical temporal patterns and regional spatial correlation, and the Hetero-Convolutional LSTM model (Yuan, Zhou, and Yang 2018) learns from the inputs as flattening vectors extracted from the images of the map. But no topological information of the underlying traffic network is captured by these models. Later, Yu et al. (2021) handled this problem by proposing a graph-based model to learn spatial-temporal, external features from a graph that represents a road network. However, most of the existing work fail to consider data fusion from multiple sources to enhance the model performance.

In this paper, we propose a Data-driven Hybrid Graph-based Neural Network (DHGNN), which aims to predict the likelihood of traffic incidents within a given region ahead of a certain time period. There are three major contributions to our work. (1) **All-in-One**: Unlike most of the existing work that one model can be applied to only one specific region or sub-network of the whole traffic network, our solution is able to predict the incident occurrence for different city-wide sub-networks by one model. Specifically, we randomly sample thousands of sub-networks from one studied traffic network as the underlying input graphs with different structures. Features are extracted regarding multiple factors for each sub-network. By learning the spatial and temporal correlations (Table 1) of incident/nonincident cases occurring in different other

sub-networks, our model can predict whether a given sub-network has an incident or not ahead of time. (2) **Data Integration:** Heterogeneous data from different sources relevant to traffic incidents, including traffic data (flow, occupancy, speed), network structures, and temporal information are integrated and normalised to form the features for different sub-networks. Our data are captured by two different types of sensors—loop detectors and probe vehicles—and, thus, the data granularity and coverage vary widely. In order to deal with the data sparsity problem in one dataset to match the density of the other, we apply the *K-Pod clustering* technique (J. T. Chi, E. C. Chi, and Baraniuk 2016) to figure out the representative samples to fill the missing data points based on similarity. (3) **Hybrid Neural Networks:** Since our two datasets cover different roads in the same region, we must construct different sub-networks to form input cases. However, a single graph neural network is insufficient to deal with one sample with two different graph structures. Thus, we propose a hybrid graph neural network that contains two sub-modules to embed two samples with different graph structures, followed by a general fully connected layer to output the prediction result. As a result, our model can achieve superior performance with 92.8% accuracy and 92.5% in AUC, which will be presented in detail in Section 4. Our model is flexible in terms of the extension to integrate other data sources by augmenting other corresponding neural networks.

2. Data Preparation

For output data, we use incident data from Queensland, Australia in 2017, where we mainly focus on *vehicle crashes* among various incident types. For input traffic data, we use two different data sources: *STREAMS* (n.d.) and *HERE* (n.d.) from Queensland, Australia in 2017. STREAMS dataset contain traffic flow and occupancy collected from loop detectors, while HERE dataset contain speed captured by GPS probes. While both are link-level measures, they use different link systems and network representations. We normalise the data in 5-minute aggregation and extract features for these two datasets separately: 16 features from STREAMS, $\boldsymbol{X^s}=< x_1^s, x_2^s, \ldots, x_{16}^s >$ and 8 features from HERE, $\boldsymbol{X^h}=< x_1^h, x_2^h, \ldots, x_8^h >$, as summarised in Table 1.

Table 1: Description of Features from STREAMS and HERE Data

Notation	Feature description	Notation	Feature description
x_1^s, x_2^s, x_3^s	p_{t-2}, p_{t-1}, p_t	x_4^s, x_5^s, x_6^s	$rp_{t-2}, rp_{t-1}, rp_t \left(rp_t = \frac{p_t - \overrightarrow{p_t}}{sp_t}\right)$
x_7^s, x_8^s, x_9^s	f_{t-2}, f_{t-1}, f_t	$x_{10}^s, x_{11}^s, x_{12}^s$	$rf_{t-2}, rf_{t-1}, rf_t \left(rf_t = \frac{f_t - \overrightarrow{f_t}}{sf_t}\right)$
x_{13}^s	30-minute flow ratio	x_{14}^s	free-flow speed
x_{15}^s	length of link (STREAMS)	x_{16}^s	level of service (STREAMS)
x_1^h, x_2^h, x_3^h	v_{t-2}, v_{t-1}, v_t	x_4^h, x_5^h, x_6^h	$rv_{t-2}, rv_{t-1}, rv_t \left(rv_t = \frac{v_t - \overrightarrow{v_t}}{sv_t}\right)$
x_7^h	speed limit (HERE)	x_8^h	length of link (HERE)

- t: 5-minute time interval;
- $p_t/f_t/v_t$: aggregated occupancy/flow/speed at t;
- $\overrightarrow{p_t}/\overrightarrow{f_t}/\overrightarrow{v_t}, sp_t/sf_t/sv_t$: are historical mean and standard deviation of occupancy/flow/speed at t;
- flow ratio: the increasing/decreasing trend across the previous 6 time slots $\frac{1}{6}\sum_{t=2}^{6}(f_t\text{-}f_{t\text{-}1})$

Rather than studying the link-level incident prediction, we focus on *sub-networks*. Specifically, we randomly sample thousands of regions with 500-m radius in Brisbane and, for each region, we construct two sub-networks representing traffic data from the abovementioned two sources, each of which contains its own set of road links with features. One challenge in using the HERE data we have was a missing data problem, where a lot of links had no speed observation for a

specific time period. To address this issue, we apply the K-Pod clustering technique to capture the representative pattern of speed for each sub-network for a given time period and use it to replace any missing data.

3. DHGNN Model

In this section, we introduce the overall framework of our model. Figure 1 shows the architecture of DHGNN, which is comprised of three major components: input module, sub-network embedding module, and output module.

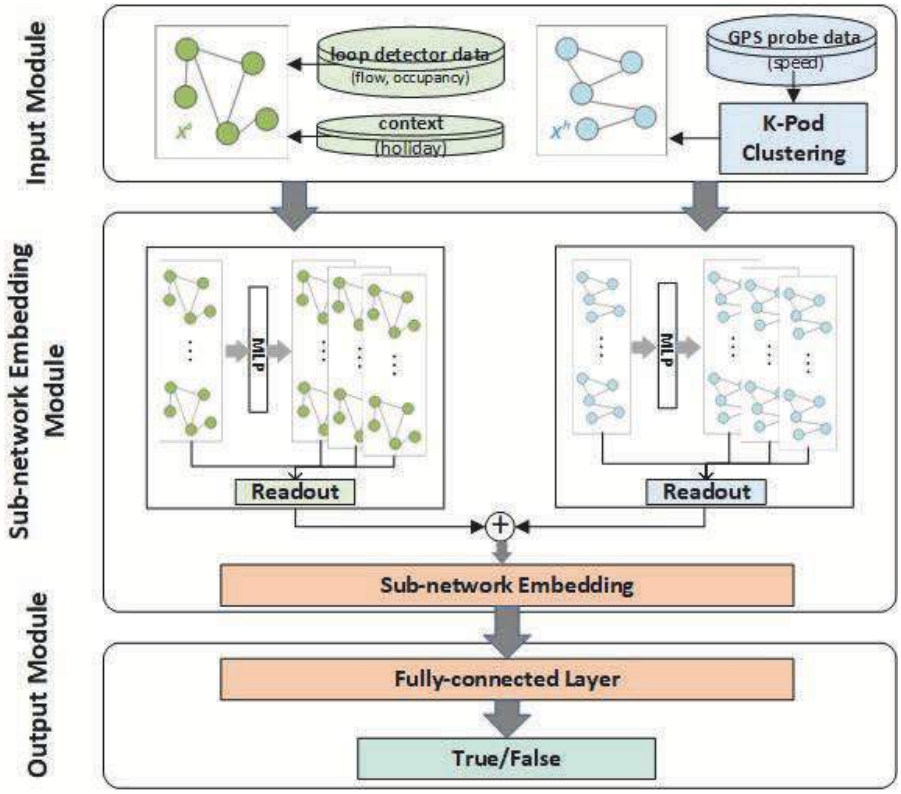


Figure 1: The overview of Hybrid Graph-based Neural Network

Input Module. As illustrated on top of Figure 1, we prepare the input data for our model by integrating multiple data sources using the approach introduced in Section 2. Then, for each case (incident/non-incident), we have two sub-networks with different graph structures but representing the same geographical region. Note that the nodes in the graph represent road links and edges indicate the connectivity among links. We attach two sub-networks with two different groups of features X^s and X^h respectively.

Sub-network Embedding Module. Next, in the sub-network embedding module, there are two graph neural networks (GNNs) taking the two featured sub-networks as input, respectively. It is expected that incidents happening on one link could be affected by traffic conditions or other factors from its nearby links. Generally, GNNs capture the dependence of graphs following a neighbourhood aggregation strategy, in which the massages of a node are iteratively updated by aggregating massages of its neighbours. After k iterations of aggregation, one node's massages then contain the structural information within its k-hop network neighbourhood. Thus, the correlations of multiple factors that influence traffic incidents in the sub-networks can be learnt by such models. In our work, we apply the ChebyGIN (Knyazev, Taylor, and Amer

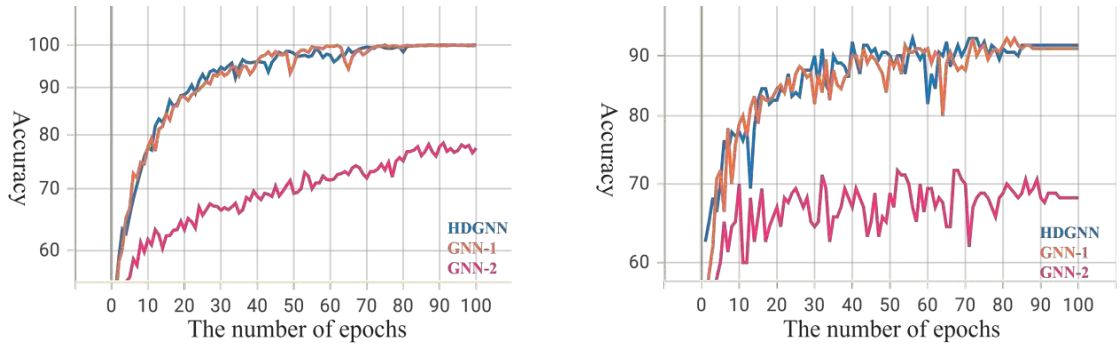
2019) model, which is a variation of the Graph Isomorphism Network (GIN) Xu et al. (2019). Intuitively, the underlying network structure is an important factor for the occurrence of traffic incidents. Compared to other GNNs, the GIN model is capable to learn the difference of graph structures from different sub-networks. As shown in Figure 1, the input sub-networks are fed into the initial graph convolution layer, where features in the nodes are propagating to their neighbours. Afterwards, before the next iteration of message passing, multi-layer perceptrons (MLPs) is used as the composition of aggregation functions. In the readout stage, where the node-level massages are summarised to generate the final embedding capturing all the information from the entire graph, rather than making use of only the final iteration, we use information from all iterations of the model to consider all the structural information. In the end, the readouts from two ChebyGIN models are concatenated to generate the embedding of two sub-networks.

Output Module. After the sub-network embedding, we apply a fully connected layer to generate the final prediction result. The output of the prediction result is either True or False representing there exists incident or non-incident within the given region ahead of time.

4. Experiments

4.1. Experimental settings

In our experiment, our model is evaluated by four metrics: *Accuracy*, *AUC* (Area Under the Curve), *Precision* and *Recall*. Regarding the prediction horizon, we make use of up to 30 minutes of historical traffic data to predict whether there will be an incident in the following 15 minutes. The traffic incident predicted by our model are mainly vehicle crash. Since traffic incidents are rare events, we adopt the undersampling method to balance the cases for incident and non-incident. There are 800 incident cases from one-year data, and we randomly sample another 800 non-incident cases from the same year. For model training, we split our dataset into three parts: 70%,10%,20% for training, validating, testing, respectively. We evaluate the performance of our model compared to two baseline models that contain only one ChebyGIN making use of loop detector & context data and GPS probe data respectively, denoted by GNN-1 (using loop detector & context data only) and GNN-2 (using GPS probe data only).



(a) Training **(b) Validation**

Figure 2: Training and Validation Performance

4.2. Prediction Performance

Figure 2 shows the accuracy during training (a) and validation (b) in DHGNN, GNN-1 and GNN-2. The performance tends to be stable when the number of epochs is around 80, showing the successful learning of our model. Table 2 reports the evaluation metrics of our DHGNN, GNN-1, GNN-2. The performance of DHGNN is better than that of GNN-1 and GNN-2,

indicating the importance of using all the information from loop detector, context, and GPS probe data, which was possible through our model's ability to integrate multiple data sources with different link representations and graph structures.

Table 2: Performance of Models on Test Set

Models	Accuracy	AUC	Precision	Recall
DHGNN	**0.928**	**0.925**	**0.910**	**0.950**
GNN-1	0.911	0.919	0.892	0.938
GNN-2	0.712	0.724	0.732	0.668

Accuracy: (TP+TN)/(TP+TN+FP+FN)
Precision: TP/(TP+FP)
Recall: TP/(TP+FN)
TP:True positive; TN:True negative;
FP:False positive; FN:False negative

5. Conclusion

In this paper, we propose a deep learning model, named DHGNN, for traffic incident prediction, which contains two GNNs sub-modules to learn the correlations of traffic data from multiple sources. Experimental results show the superiority of our hybrid model compared to the one with one GNN making use of a single data source. In the future, we will extend our model by augmenting another neural network sub-module integrating more data sources, e.g., weather data.

6. Acknowledgements

The authors gratefully acknowledge the support of Australian Research Council (ARC), Queensland Department of Transport and Main Roads, and Transmax Pty Ltd under the ARC Linkage Project on Real-time Analytics for Traffic Management (LP180100018).

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Pavement monitoring: A comparison of smartphone and accelerometer sensors [77]

Amir Shtayat *(RMIT University),* ***Sara Moridpour*** *(RMIT University) and* ***Berthold Best*** *(Technische Hochschule Nürnberg Georg Simon Ohm).*

Abstract

The increase in vehicular traffic volume on our roads intensifies the need for comfortable and safe riding. To satisfy the comfortable and safe riding needs, frequent inspections of pavement health statutes is needed. Sustainable pavement condition comes from accurate monitoring, accurate assessment, and routine maintenance actions. Monitoring the pavement condition is a technique used to obtain clear details about the level of damages, roughness, and smoothness of the road surface. A regular monitoring system can help transport agencies and governments determine the current and future pavement conditions. In this study, two monitoring devices, including a smartphone application and an accelerometer sensor, are used to collect pavement vibration data for a local road. In addition, a comparison between the devices is presented in terms of accuracy, efficiency, and best locations to be mounted. The results show that both methods provide accurate monitoring results with some considerations on the best mount locations.

Multi-level trajectory clustering for identifying path choice set [85]

Chintan Advani *(Queensland University of Technology),* ***Ashish Bhaskar*** *(Queensland university of technology) and* ***Md. Mazharul Haque*** *(Queensland University of Technology).*

Abstract

Path choice set identification is an essential requirement for route choice modelling and traffic assignment. Availability of detailed vehicle trajectories from large datasets such as Bluetooth MAC Scanners (BMS) unleash opportunities for empirical identification of the path choice set for drivers on the urban road networks. Observed real paths from large trajectory datasets are huge and diverse. For ease of route choice modelling, there is a need for realistic representation of the observed paths. Addressing the need, this paper proposed a multi-level trajectory clustering framework for a realistic representation of the path choice set from observed paths from a large trajectory dataset. The algorithm minimizes the errors induced due to clustering and identifies the representative path from each cluster. As proof of concept, the algorithm is applied on real BMS based vehicle trajectories from Brisbane, Australia and the identified path choice set is presented.

SESSION 2D: COVID

The impacts of COVID-19 pandemic on the volume and pattern of public transport trips in the Greater Sydney Area [45]

Seyed Sina Mohri *(The University of Melbourne),* ***Neema Nassir*** *(The University of Melbourne),* ***Russell Thompson*** *(The University of Melbourne) and* ***Michael Stokoe*** *(Transport for NSW).*

Abstract

The COVID-19 pandemic and its following restrictions changed the volume and patterns of Public Transport (PT) trips in the Greater Sydney area. This study explores the trip volume changes by applying comparative and statistical analyses on hourly PT fare card (Opal) transactions data for trips in 2019, 2020 and 2021 (up to March). The findings show that total PT trips in 2020 declined by 45% in comparison with 2019, with the maximum decline being in April 2020 at 79.4%. Although there was a sharp decline in PT demand for 6 weeks in March and April 2020, the demand has smoothly recovered by March 2021. Comparing the skewness and kurtosis of PT trip histograms in morning and evening time periods resulted in interesting findings. It is observed that the time PT commuters spend at their workplaces was decreased during COVID-19. The change in spatial patterns of PT trip production and attraction were quite similar, where a yearly drop between 34% to 59% in volumes of both PT trip production and attraction was recorded for every zone in the network. Clustering SA2s based trip distribution patterns in 2019 and 2020 revealed that several parts of the cluster within the CBD core were separated and either joined to other clusters

or formed new clusters. Correlation analysis showed that decline in PT use had a direct relationship with income levels, with zones having higher income distributions displayed the highest decline in PT ridership, whereas lower income zones were more likely to continue using PT through COVID-19 outbreak times.

The impact of working from home on travel demand: a methodology and preliminary estimates from Victoria [49]

Tim Bryant *(Victorian Department of Transport),* ***Hugh Batrouney*** *(Victorian Department of Transport) and* ***James Eunson*** *(Victorian Department of Transport)*

Abstract

Working from home behaviours established during the Covid 19 pandemic will likely endure at materially higher levels than transport demand forecasts have historically assumed. Applications of strategic transport models typically assume trip generation functions calibrated to historic household travel survey data will remain unchanged in the decades ahead. It will be several years before a new steady state of travel behaviour is established and models can be recalibrated and validated to observed data. In the meantime, informed assumptions and innovative methods are required to use strategic transport models to forecast demand that incorporates long term working from home impacts. Our preliminary central scenario assumes 29 per cent of current Victorian jobs are suited to long term working from home, and workers in those jobs will work an additional 1.8 days per week from home compared to before the pandemic began. Jobs suited to working from home are heavily concentrated in the CBD and inner-city areas, while the location of workers employed in those jobs are more dispersed across Greater Melbourne and regional areas. We apply a tailored method to integrate these parameters with employment projection inputs and the four-step modelling process used in the Department of Transport's Victorian Integrated Transport Model (VITM). As well as reducing demand for work commute trips, the method redistributes demand for some trips made during the workday – previously assumed to made from workplaces – to occur from home locations. Preliminary estimates reflect an 11 per cent reduction in daily work commutes in Greater Melbourne, representing two per cent of total daily weekday trips. Travel demand in inner areas in peak periods are disproportionately affected, with seven per cent fewer trips to the Melbourne CBD.

Pedestrian activity in Melbourne, Australia in response to COVID-19 [40]

Joel Hermann *(Monash University),* ***Alexa Delbosc*** *(Monash University) and* ***Mahsa Naseri*** *(Monash University)*

Abstract

The COVID-19 pandemic has considerably influenced the travel behaviours of the entire global population. One of the most significantly impacted areas of Australia in terms of mobility is the Melbourne CBD. Melbourne has been subject to several government-imposed lockdowns and is critical to Australia's economy, yet there is no existing research which focuses on how pedestrian activity within the city has changed in response to COVID-19. The aim of this paper is to quantify the magnitude of the change in pedestrian activity across the Melbourne CBD, and to determine whether these volumes are on course to return to pre-COVID-19 levels. The paper draws on data from the City of Melbourne's Pedestrian Counting System from January 2019 to April 2021. We found that during the worst parts of lockdown, Melbourne recorded pedestrian volumes that were approximately 90% lower than the corresponding month in 2019. During a typical weekday in 2020, pedestrian volumes during morning, lunchtime and evening peaks were particularly impacted. As of April 2021, the City of Melbourne was still recording pedestrian volumes that were well below 2019 levels. Weekday pedestrian volumes continue to lag behind weekend ones, confirming that weekday activity should be of primary concern for key policy makers. These insights are likely to be valuable to the City of Melbourne, as well as other major global CBDs, which are all likely to be facing similar decreases in activity due to the pandemic. It is hoped that these findings will enable key policy makers in Australia and around the world to make informed decisions about how best to position their cities for a swift recovery.

SESSION 3A: SOCIAL/ECONOMICS

The lived experience of transport limitations in Melbourne's growth areas [57]

Annette Kroen *(RMIT University) and* ***Robin Goodman*** *(RMIT University)*

Abstract

In Australia's large cities transport infrastructure and services are unevenly distributed. Public transport, in terms of both provision and frequency of service, is concentrated in inner, and to some extent middle, suburbs. In recent years the provision of infrastructure for active transport in new suburbs has improved, but destinations that are at a walkable distance are scarce and cycling is viewed by many as unsafe. Along with other factors, including differing land use patterns and densities, this means that residents in outer areas have little choice but to rely predominantly on private motor vehicle travel, exacerbating a range of disparities which already exist across the metropolitan areas of major cities. This paper reports on the lived experience of residents in two of Melbourne's growth suburbs in relation to transport, access and mobility, against the background of Melbourne's current strategic plan promoting local living and the notion of a 20-minute neighbourhood. The findings are drawn from a survey and interviews of residents which were undertaken for a three-year project on the early delivery of equitable and healthy transport options in new suburbs.

The Logan DRT trial – Socio-demographic analysis of users [19]

Ben Kaufman *(Griffith University Cities Research Institute),* ***Malin Backman*** *(Microtransit Consulting),* ***Matthew Burke*** *(Griffith University) and* ***Abraham Leung*** *(Cities Research Institute, Griffith University).*

Abstract

This paper outlines the results of a survey into socio-demographics of users of the Logan Demand Responsive Transit Trial in Queensland, Australia. Users of the service were surveyed to develop greater knowledge on the impacts of on-demand services on residents in low density environments. The survey was deployed prior to Covid-19, and collected responses from 400 individuals who had registered to use the service. Results indicate that most users lacked personal automobility and access to traditional fixed route public transit. These same users found accessing the on demand service easy, and experienced increased access to basic goods and services. The Logan DRT Trial provides serves as a usual model to study when deploying on-demand services in low population density environments.

SESSION 3B: PUBLIC TRANSPORT

Beyond prohibition: Policy options for pets on public transport [79]

Jennifer Kent *(The University of Sydney) and* ***Corinne Mulley*** *(The University of Sydney)*

Abstract

Well behaved dogs in cities are good for society and good for individual health. Responsible dog ownership, however, generates trips. If these trips cannot be accommodated on foot or by public transport modes, they will likely be accomplished by car, contributing to the perpetuation of private car use as the dominate mode of transport in cities around the world. Many cities recognise that accommodating dogs on public transport is part of the provision of a functional, useful and popular, sustainable transport system. Others, however, maintain strong restrictions on the carriage dogs, indicating hesitancy. Sydney, Australia, is one such hesitant jurisdiction, and the city been the subject of a number of surveys examining the barriers to a dog friendly policy for travel on its public transport network. This paper reviews, in detail, policies for five cities around the world that permit dogs to use the public transport system. Using the understanding of barriers to policy change developed for the Sydney case, the paper seeks to generate ideas that can be used by Sydney and other cities seeking to open public transport up to a wider and more diverse range of trips. The paper looks to 'dogs smell and so I don't want to travel near them'; 'dogs create mess which needs cleaning'; 'dogs can attack people' and finally, how to deal with allowing dogs onto a system, where previously they are banned, when the system is capacity constrained. Specific policy approaches are provided and the paper concludes with reflections on barriers to potential policy change.

Research issues arising from a review of themes at the formal-informal transport interface in developing countries [105]

David Ashmore *(TSA Advisory & University of Melbourne) and* ***Philippa Chandler*** *(University of Melbourne).*

Abstract

RESEARCH PAPER Informal urban transport is provided by private operators as a direct service to the market with low or no formal regulation. Formal transport is regulated in some capacity – it officially exists, is registered – through contracts, permits, or licenses. An operator may not just enter the market. The informal-formal transport interface occurs in situations where the two forms of provision interact, typically around the 'last mile' – getting from a formal drop off point such as a metro station, to a final destination on an informal mode. Where informal transport is being studied, two typical scenarios present themselves from a supply side. The first scenario is that of a city where there is no existing or planned formal transport corridors or spines. In this instance the emphasis is one of accepting informal transport as the sole mode - a given which is unlikely to change due to funding or capacity constraints making formalised mass transit unlikely. In this case understanding the sector's inner dynamics more and gauging how its outputs can be improved for greater public good, are key focal points. The second scenario is where the formal and the informal coexist or are about to co-exist. In contemporary transport policy these are often due to bus rapid transit systems being introduced into an area where there is existing informal supply. This dualised or hybridised situation is a far more complex avenue of research than accepting informality as the sole provider of transport, as it leads to questions of tradeoffs between the two sectors and presents dilemmas relating to the desirability and existence of the informal and how it should support the formal. This paper discusses literature pertaining to each scenario and concludes with a series of research questions to facilitate the development of further research into this critical area.

SESSION 3C: NEW TECHNOLOGY, ATTITUDES AND BEHAVIOUR

Attitudes towards automated vehicles: a Dutch-Australian comparison [24]

Tony Arnold *(University of Sydney),* ***Stephen Greaves*** *(University of Sydney),* ***Michiel Bliemer*** *(University of Sydney),* ***Dea van Lierop*** *(Utrecht University) and* ***Dick Ettema*** *(Utrecht University)*

Abstract

This paper explores attitudes towards automated vehicles (AVs) in two contrasting urban contexts: car-centric Australia and bicycle-centric the Netherlands. Semi-structured interviews were conducted with 15 participants in each country, covering issues such as ownership, sharing, safety and use for various trip purposes. Participants in both locales expressed concern that AVs are not currently safe, would strip control from drivers and result in a less-human world. Australian interviewees expressed concern about liability, the deskilling of the population and the practicality of electric AVs. By contrast, Dutch interviewees expressed concern that owning an AV would be 'showing off'. Key benefits of AVs expressed by participants of both nations included ease of use, ability to multitask, relief from parking hassles, improvements in traffic and convenience. The findings suggest that an understanding of environmental and cultural contextual influences provide an important dimension to the acceptance and potential adoption of AVs.

How governments influence autonomous vehicle (AV) innovation [34]

Daniel Schepis *(University of Western Australia),* ***Sharon Purchase*** *(University of Western Australia),* ***Nick Ellis*** *(Durham University),* ***Doina Olaru*** *(University of Western Australia) and* ***Brett Smith*** *(University of Western Australia).*

Abstract

While autonomous vehicle (AV) technology is forecast to widely disrupt transport systems, governments' roles in influencing innovation trajectories has not been examined holistically. This empirical study analyses the perceptions of 34 professionals from

government and non-government actors in the U.K and Australian contexts. Preliminary findings identify three main categories of government roles: regulator, facilitator and participator. The paper discusses the implications for AV innovation within each context. This research provides a valuable contribution to understanding how local policy environments around the world might shape AV innovation.

Decision field theory: an extension for real-world settings [70]

Thomas O. Hancock *(University of Leeds),* ***Stephane Hess*** *(University of Leeds),* ***Charisma F. Choudhury*** *(University of Leeds) and* ***Panagiotis Tsoleridis*** *(University of Leeds).*

Abstract

Decision field theory (DFT) is a model that was originally developed within the context of cognitive psychology to explain phenomena not expected under classical choice models. This meant that the model was initially designed to explain choice behaviour observed under controlled laboratory settings. Recent work has improved the mathematical foundations of DFT, such that it has become a tractable and more rigorous model that is easier to apply to a wider variety of choice contexts. In particular, the inclusion of attribute importance parameters has led to successful applications to stated preference data including travel mode choice. However, thus far, implementations to real-life behaviour have been limited. The aim of this paper is to extend decision field theory such that it can take further steps towards accounting for real-world behaviour and a wider variety of contexts, in general. First, we give theoretical extensions for the model, demonstrating that relaxing the assumptions around the normal error term within DFT can lead to more flexible structures. Second, we demonstrate on two large-scale case studies of revealed preference mode choice behaviour in the UK that DFT can incorporate a range of sociodemographic variables. Thirdly, we demonstrate that our new `heteroskedastic' DFT model substantially outperforms the original version of DFT, as well as alternative econometric choice models.

SESSION 3D: TRANSPORT HISTORY

Observations on electric vehicle's first hurrah - horse, steam and electric tramway technology adoption rates in the UK 1860s to 1960s [108]

Robert Smith *(East Economics)*

Abstract

The momentum for the adoption of electric vehicles is currently the strongest it has been for over 100 years. This paper provides data and observations on electric vehicles' first major success – the rise and fall of the electric tram. Using a data set from 1860s to 1960s for the progressive adoption and abandonment of horse, steam and electric traction technologies in towns in the United Kingdom graphs show the time path of tram technologies and are manipulated to show strong similarities in take-up rates consistent with a simple S-cure innovation path. However, observations on lessons from the history of the period and the path of electric trams highlights that assuming simple take-up rates for new technologies misses key issues and care needs to be taken in forecasting a similar rise of new electric vehicles

Overcoming the Brisbane River: The Cross River Commission of 1926 [75]

Brendan O'Keeffe *(Brisbane City Council)*

Abstract

The Cross River Commission report published in 1926 was the first major strategic transport planning document published by the newly formed Brisbane City Council (Council). It recommended 12 new crossing points across the Brisbane River to relieve congestion and the vulnerability of the city with only one crossing point for general traffic. Its first two recommendations were implemented within 15 years but not without controversies over responsibility for delivery, affordability and ideological arguments over tolls and private sector involvement. Post-war the focus was on responding to the growth of the motor car as the primary mode of transport for the city and the development of freeways and expressways.

More recently, a renewed focus on public and active transport to cater for growth in the inner city had led to implementation of new crossings, culminating in Council's Green Bridges Program and Brisbane Metro and the Queensland Government's Cross River Rail Project. Nearly 100 years later, some of the recommendations of the Cross River Commission are still in development.

A retrospective on the Adelaide area transportation study [13]

Robert Nairn *(Retired)*

Abstract

This paper discusses the history of the Metropolitan Adelaide Transportation Study (MATS) which published its report in August 1968 and the subsequent community involvement and political activities that led to the eventual demise of its freeway components. The almost complete rejection of the planned freeways is probably unique in Australian transportation history and the process of community involvement and political effort preceding its demise is distinctive in many respects. There can be no doubt that the State Government of the day and the South Australian Highways and Local Government Department did everything they possibly could to win support for the MATS plan in Parliament and with the public. The plan was robust and clearly presented. The study was conducted with a high morale, with innovative achievements and precious, scarce learning opportunities for those who took part. It ended with a harsh lesson in deflated optimism, political disillusionment and lessons in social planning. Few of the plan's many recommendations received adverse criticism but the intense objections to the plan centred on the social impact of the freeways. The public opposition grew to a stage where it attracted strong political interest and, despite the fact that land acquisition had commenced, with subsequent changes of State Government, the plan for freeways was effectively rejected.

ABSTRACTS
THURSDAY 9 DECEMBER 2021

PLENARY 2

9.10am – 9.35am

The future of transport in Brisbane (P03)

Cr Ryan Murphy, Civic Cabinet Chair for Transport, Brisbane City Council

The Schrinner Council is currently embarking on Brisbane's largest ever investment in public and green transport, including the game-changing Brisbane Metro project and new green bridges at Kangaroo Point, Breakfast Creek and West End. The future of transport in Brisbane is human-centred mobility – from Brisbane Metro's public realm improvements, to Australia's first shared e-mobility scheme and an iconic, modern river ferry network – all of which will support the Brisbane 2032 Olympic Games.

9.35am – 10.00am

Artificial intelligence and F1 Grand Prix - What's that got to do with Intelligent Network management (P04)

Dr Kellie Nuttall, Partner, Deloitte Australia

Digital Twins have been two buzz words dropped readily into conversations about the future of intelligent network planning and operations.... but what are they, what do they do, and how good are they really in a transport context?

In this keynote, learn how applications of digital twins supported by advanced simulation and AI in other sectors like F1 and aviation are now finding value on the ground in managing complex multimodal transport networks.

SESSION 4A: ACTIVE TRANSPORT

Transport as recreation - Road sharing in regional Victoria [43]

Robbie Napper *(Monash University),* ***Marilyn Johnson*** *(Monash University),* ***Vanessa Johnston*** *(RMIT University) and* ***Jenny Corser*** *(Alpine Shire Council)*

Extended Abstract

1.Introduction

This research aims to increase road user safety for bicycle riders in mountainous on-road environments. In this work we identify and implement ways of enhancing safety in this setting through an interdisciplinary study in sociology, law and design. Cycling tourism generates $130 million annually in the North East region of Australia's state of Victoria (Ride High Country, Personal Communication), a significant share of the Gross Regional Product of $592M in 2019 (DJPR 2021). Mountainous topography and natural beauty of this region are key attractions to the area. Locals and visitors seek out bicycle riding opportunities including recreational and professional training in the category of "road cycling". This is set in a context of other bicycle recreation such as off-road path riding on rail trails, mountain bike riding in forested areas, and unpaved gravel road riding. When road cycling, the rider engages with topographic and dynamic road use experiences that are almost always dependent on using paved roads. These roads are also used by motor vehicle drivers.

Mountainous topography attracts residents and visitors to the region, both of which use the road network for varying purposes. Vehicles such as logging trucks, private cars, tractors, and bicycles share the road space for a diverse array of purposes, from tourism travel, business and commerce, freight, and recreation. This diversity of purposes and vehicles, when combined with the features of mountainous roads, leads to some challenges in how the road system operates. The focus of this research is on behavioural aspects of recreational road cycling and motor vehicle users, in which we aim to determine methods of encouraging safe road sharing. The interdisciplinary research approach is framed as a combination of social, legal and design aspects, outlined below.

There are stark differences between the vehicles sharing these roads. The bicycle is a lightweight two-wheeled, single-track, human powered vehicle (Wilson and Schmidt 2020) whereas the motor vehicles on the same roads are different in nearly every regard, being heavy, four or more wheeled, multi-track and motorised. Thus, while able to reach speeds equal to those of motor vehicles on descents, ascending the same mountains may reduce a bicycle and rider to just a few kilometres per hour. Being narrower, the bicycle takes up less lane width, however the remaining space may not be sufficient for a motor vehicle to legally pass. There is a very large difference in the kinetic energy and protection provided by bicycles and motor vehicles, the former being one type of vulnerable road user. Although the concept of roads, and paved road technology pre-dates the motor vehicle (Reid 2015), the current design of roads in Australia tends to satisfy the direct needs of motor vehicles, and only

accommodates the spatial, rather than dynamic and safety needs of bicycle riders (Austroads 2016).

Put simply, a road wide enough for a motor vehicle is wide enough for a bicycle, however it is not always wide enough for these two road users travelling in the same direction to pass safely, especially considering that Victoria now has road rules that require drivers keep a minimum distance when overtaking cyclists. In the Alpine Shire, road sharing behaviour was identified as a source of tension between the safety objectives of these road user types, and education seen as a way of changing behaviour to improve safety outcomes. The Alpine Shire was awarded funding under the TAC Community Road Safety Grant Scheme to undertake the research and development of an education program to improve road safety in this situation.

2. Method

The focus of this road user education was behaviour and culture change, ruling out built infrastructure solutions. As such, the research used sociological methods to discover locally pertinent factors in relation to cyclists and drivers sharing the roads. An interdisciplinary methodology was used in the project, combining approaches from sociology, safety science, law and design (Napper, Johnson & Johnston 2021) to understand the technical, social and legal factors.

The project had three key parts. First, we used sociological methods of focus groups and qualitative surveys to generate information and then analysed these results in the interdisciplinary setting outlined above with an aim of understanding the problem from each perspective. Second, we used these findings to design and execute an educational strategy and then bring this to life in a media campaign. Third, we carried out a post-campaign survey to determine the effectiveness of the work and help to determine possible future steps. Ethics approval for low-risk human research was obtained from Monash University and RMIT ethics committees.

3. Results

3.1. Stage one - understand the problem

3.1.1 Focus group

An initial focus group with Alpine Shire stakeholders in road safety was undertaken in August 2020. The participants were recruited from key local stakeholders and in consultation with the Alpine Shire Council and included representatives of local schools, businesses, police, shire councillors, and the regional tourism authority. A semi-structured approach was followed using predetermined questions to build an understanding of the local aspects of road sharing.

Findings from the focus group highlighted elements from all aspects including social, legal and design factors. While legally a bicycle and rider are a vehicle and have the same legitimacy as other road users, this is not always recognised or accepted.

Interestingly, trip purpose was raised as a point of distinction that contributed to “legitimacy” with people driving cars having greater legitimacy than people riding bicycles. Yet trip purpose is difficult to distinguish by visual means alone. A car being driven for recreational purposes bears very little difference to one being driven for commuting. Road cycling is an activity which can be both recreational and professional and a person may ride the same bicycle in the same clothes to commute or for a recreational trip. Yet there is a tendency to identify all bicycle trips as recreational because of a cultural framing of cycling as sport

(Bruntlett and Bruntlett 2018) and this further erodes the legitimacy of bicycle riders as road users and their classification as such in Victoria's road rules. Whereas this kind of erosion based on purpose does not occur for motor vehicles in analogous situations - for example a car towing a caravan or camper trailer - which despite clear recreational purpose, maintains legitimacy as a road user as part of the tourism industry of the region.

The focus groups showed that the challenges around road sharing in the Alpine Shire were indeed a mixture of considerations in the local area, such the importance and perceived hindrance to the local economy of tourism, who is getting in the way of who, as well as how the road rules, local culture, and road design, affect behaviour. The discovery of these issues provided the basis for the qualitative survey.

3.1.2. Survey one - pre campaign

Informed by the findings of the focus groups, we developed a qualitative survey, aimed at people who live in or visit the Alpine Shire. The aim of the survey was to understand the views of different road users in different situations - for example prior knowledge indicates that nearly all adult bicycle riders drive cars. We also wished to test some perceptions of road sharing and the value of cycle tourism to the region. Incentives were offered for completed surveys (prize draw, one of three $100 gift cards).

In total, 569 completed surveys were received. Almost all respondents (98%) drove motor vehicles regularly, with 82% driving and riding frequently. Key findings from the pre-campaign survey include: 86% of respondents underestimated the value of cycle tourism to Victoria's North-East region; when driving, respondents were willing to wait 4 minutes and 6 seconds ($\bar{x}\ time$)to pass a cyclist while driving; top three reasons why some roads are more suited to driving than cycling: lack of road shoulder, narrow roads, high speeds, and; the most popular methods of communicating with other road users when driving was: wave (hand or one/two fingers)(66%) or nod (15%).

3.2. Stage two - campaign

Focus group and survey results showed that road users viewed one another as "vehicle users" of a particular type, rather than as people, revealing an opportunity for the education campaign to focus on these people, rather than their roles as drivers or cyclists. In addition, the survey confirmed the hypothesis that gesturing while using the road could be a key part of this message. We engaged DGB Media group to provide the expertise in translating this intent to forms suitable for mass-media while capturing the intent of the education campaign and factually based on the research discoveries of stage one.

We collaborated with the Amy Gillett Foundation and DGB on the creation of the media campaign, honing down to a single concept from four possible options. The concept of "Live, Drive, Ride Like a Local" was developed in this process. The centrepiece of the campaign is a short film telling the stories of locally well-known Alpine Shire residents (for example, the bank manager from Bright, a larger town in the centre of the region). The film, as per the whole campaign, emphasises two key messages: that people riding bicycles in the Alpine Shire are "normal" and consist of a strong proportion of local people; and that gesturing is an important signal to recognise use of the road between road users, to build trust and a capacity to share the roads, as well as meeting the legal obligations of road use.

The collaboration also yielded a logo, graphic design elements, photography, audio of interviews, copywritten assets and event materials which we used to create collateral such as postcards and event gantries.

The Live, Drive, Ride Like a Local campaign was launched at the 2020 Alpine Classic cycling event in Bright, debuting at two outdoor cinema events, full page newspaper advertisement, event entry gantry and postcards. The short film has a permanent home on youtube (https://www.youtube.com/watch?v=5aPflYraKtw) and is ready to be deployed to other channels, for example cinema or television advertising.

3.3. Survey two - post campaign

Following the campaign we carried out a post-survey to determine whether, and to what extent, the messages of the campaign could be recalled by the general public. We also used the opportunity to evaluate the value of emphasising local people and places in the campaign.

In total, 97 valid responses were completed, with a greater proportion of non-cycling respondents than survey one. While 97% of respondents drive regularly, only 54% of respondents both drive and ride frequently. Although the majority of respondents (70%) had seen the campaign before the survey, the video was embedded in the survey and all respondents watched it before answering campaign specific questions. The survey showed that the top two messages from the campaign video were that “people riding bikes are normal people” and “mutual respect in road sharing”. These are aligned with the campaign aims and initial research findings. Other important results are described in table one, below.

Table 1: Key results from post-campaign survey

Statement	Result
Drivers and cyclists need to be educated about sharing the road for the local conditions.	92% agree
It is important to include people who live in the local area in a road safety campaign.	82% agree
It is important to include the local area in a road safety campaign.	91% agree
Behaviour change: wave to drivers	31% are more likely

4. Discussion

This project delivered a successful campaign that humanised cyclists. The evaluation reported that after watching the main video of the campaign, people had good recall of the main messages, and were more likely to exhibit behaviours which contribute to safer road sharing. In addition to these core findings, the campaign was successful in the inclusion of local people and local places to locate the campaign in place, as well as in reference to local people who are not actors.

When we consider the findings of each research stage there are three additional, unexpected discoveries from this research.

From a social perspective, we identified strong opposition by some people to non-motor vehicle use of the roads in the Alpine Shire. Responses from a small but vocal cohort included factually false but personally held understandings of what roads were built for (i.e. roads are for cars) and how road should be used according to the road rules. Follow up research in the public realm (e.g. Facebook profiles) also identified aggressive and physically violent messaging about cyclists from people who were opposed to a spectrum of social progression initiatives, not just sharing the road with road cyclists. This identifies an area for future research.

When analysing results from a legal and design perspective, we discovered that often the road design does not provide a suitable environment for sharing, in particular, speed. When we consider the speed differential of ascent when travelling up a long, mountainous road, between a cyclist (<10km/h) and a motor vehicle (60km/h), there are immediate consequences in a safe system. Survey responses included language such as "I had to overtake over double-white lines" to create a narrative in which a prohibited activity is transferred into a permitted one. This strongly relates to the social problem of how different road users construe themselves and others as having not only different amounts of legitimacy in using the road (despite being equally legitimate under the law), but also having different levels of justification to engage in breaking the road rules (despite having equivalent legal obligations).

Finally, the research also uncovered a potential infrastructure improvement that was viewed as mutually agreeable to both road cyclists and drivers. Road cycling by its very nature depends on using the road - as opposed to a shared recreational path or rail trail, which serve other purposes. Providing a smooth, swept, wide shoulder on key routes was nominated by several survey respondents as a solution which would provide road space for different road users while not undermining the appeal of the road profile for road cycling.

5. Conclusion

Through this project our research determined that humanising road users and encouraging communication through gestures would be a strong basis to an education campaign aimed at changing road user behaviours and attitudes. Based on research into the road users of the Alpine Shire, we developed a campaign and tested the results, showing that road users were more likely to perceive people riding bicycles as normal people, and to wave to each other. We also identified that further research is needed, particularly into the social issues of negative attitudes towards dislike cyclists, possible infrastructure improvements, as well as deepening the knowledge base at the intersection of safety, social issues, the law and road design.

7. Acknowledgements

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Maintaining shared automobile, bicycle, and pedestrian facilities: Towards a multi-objective approach [103]

Sue Mcneil *(University of Delaware),* ***Yuanchi Lee*** *(University of Delaware),* ***Shelley Stoffels*** *(Pennsylvania State University),* ***Elise Miller-Hooks*** *(George Mason University),* ***Pengsen Hu*** *(Pennsylvania State University) and* ***Qiang Chen*** *(George Mason University)*

Abstract

Over the past three decades, the importance of providing an efficient multi-modal transportation system has been recognized in terms of the contributions to quality of life, livability, healthy living, and sustainability. Little attention has been paid to maintenance and rehabilitation decisions and supporting non-motorized modes, of travel, particularly bicycle and pedestrian, during maintenance and reconstruction. Given the different maintenance needs for different types of facilities, this research explores the issues involved in accounting for the disruption to all modes and the strategies for maintenance decision-making and scheduling that recognize all users. The objective is to develop strategies for selecting maintenance actions for bike, pedestrian, and auto facilities that share the right of way accounting for disruptions whose impacts cascade across modes. The proposed strategies build on principles of asset management and work with the construct of the transportation system as a sociotechnical system. Given that these decisions are commonly the responsibility of local governments with few resources, a secondary objective is to develop guidelines to help local governments develop strategies without an onerous data collection and modeling effort. This presentation motivates this effort and presents a preliminary formulation.

A GIS-based walkability analysis for the Greater Adelaide Metropolitan area: An evaluation of the AURIN walkability Index [109]

Arsham Bassiri Abyaneh *(UniSA Creative, University of South Australia),* ***Andrew Allan*** *(UniSA Creative, University of South Australia),* ***Johannes Pieters*** *(UniSA Creative, University of South Australia),* ***Sekhar Somenahalli*** *(UniSA STEM, University of South Australia) and* ***Ali Soltani*** *(UniSA Creative, University of South Australia)*

Abstract

Currently, a considerable amount of attention has been given to walking as a human-powered and ecologically friendly mode of transportation that can address the public health and environmental issues faced by contemporary cities. Although a rich body of research has been developed in recent decades aiming to shed light on how the built environment can encourage walking using Geographic Information Systems (GIS), gender and equity issues are evident in the research on walkability. The Australian Urban Research Infrastructure Network (AURIN) has recently developed a GIS-based spatial toolkit to analyse and compare the level of walkability across Australia's metropolitan areas. This study analyses and visualises the level of walkability in each Statistical Area Level 3 (SA3) of the Greater Adelaide metropolitan area using the AURIN walkability index. Furthermore, it adds public transport accessibility to the AURIN toolkit to improve its robustness. Finally, it conducts a gender-based analysis on the relationship between different criteria of the AURIN index including connectivity, land-use mix and population density as well as the modified walkability index against the walk-to-work behaviour of the population. The findings indicate that Adelaide City and Port Adelaide – East are the

most walkable and Gawler - Two Wells and Adelaide Hills are the least walkable SA3s of the study area. Developing and maintaining the datasets of other aspects of the built environment such as the effects of terrain, perceptions of crime, perceptions of comfort and the perceived visual interest as well as a more detailed socio-demographic profile of the pedestrians can be suggested for further studies on the available walking data via the AURIN portal.

Network assessment for cycling, the Inner Adelaide Case [37]

Ali Soltani *(University of South Australia),* ***Jaswanth Lella*** *(University of South Australia),* ***Masoud Javadpoor*** *(Shiraz University) and* ***Andrew Allan*** *(University of South Australia)*

Abstract

Cycling is a fantastic method to get about while also being environmentally friendly. It improves urban mobility, liveability, and public health while reducing traffic congestion and pollution at the same time. Hillier's (1984) research of spatial syntax is suggested for going beyond the street network and looking at how network layout influences travel behaviour choices. The goal of this study is to see if there's a link between street network morphology and commuters' desire to ride their bikes to work in Adelaide's inner suburbs. To obtain a better understanding of the implications that street network geometry may have on the estimation of cycling to work, two ordinary least square (OLS) models including both base socio-economic factors and street network variables are developed. The analysis showed that adding space syntax measure variables to the equation enhances the goodness of fit for cycling to work. When it comes to explaining variations in cycling to work, the model that incorporates spatial syntax features has a greater (about 10%) explanatory power. The findings may be seen as an evidence-based statement that planners and policymakers can use to help them make decisions about how to improve the design of bicycle networks in suburban areas.

SESSION 4B: PUBLIC TRANSPORT

The catalytic effects of public transport infrastructure on urban renewal: the case of level crossing removal projects in Melbourne [118]

Abdulrhman Gbban *(Monash University),* ***Md Kamruzzaman*** *(Monash University),* ***Alexa Delbosc*** *(Monash University) and* ***Selby Coxon*** *(Monash University)*

Abstract

Transportation and land use are closely linked, and therefore, changes in public transport infrastructure can influence the land use and activities of the surrounding area. Understanding these effects enables developers to implement transportation services that are most useful to the local area and residents as part of urban renewal projects. However, the by-product effects of transport infrastructure on other sectors, such as land use, have been minimally researched. This paper aims to present the first empirical insight into the catalytic effects (i.e. impacts on other industries) of improvements to public transport infrastructure on urban development, redevelopment, and regeneration. The study employed a case-control study design method; a total of 13 cases of level crossing removals in Melbourne were selected, along with 13 control sites. Changes in land use patterns were measured between the case and control sites, between 2015 (prior to level crossing removal) and 2020 (at least two years after the removal), using historical Nearmap, complemented by Google Earth, Google Street View, and official land use data. Difference-in-difference (DiD) models were estimated to identify the effects of the level crossing removal on the surrounding built environment. The study found that the case sites experienced a statistically significant increase in commercial land (DiD score = 10.71%), open space (7.67%), and parking (4.95%), at a spatial distance of 100 metres from level crossing removal; however, a decrease in residential land was found at 200 metres (-28.5%), and railroad on the ground (40+%) at all spatial distances. Overall, these changes are expected to improve the quality of life for residents living near the case sites.

Examining if reliability and efficiency are key 2 parameters for customers in the arbitration of 3 service quality targets [136]

Mathew Hounsell *(UTS)*

WITHDRAWN

Abstract

This paper examines the theoretical frameworks of public transport service delivery and especially the Strategic Triangle and Service Quality Loop. This paper then considers the need for efficient and reliability from the customer and operator perspective and posits that Statistical Process Control could support continuous improvement of reliability and efficiency.

How can we build trust and collaboration among the stakeholders in a MaaS eco-system? [53]

Thiranjaya Kandanaarachchi *(Institute of Transport and Logistics Studies, University of Sydney),* ***John Nelson*** *(Institute of Transport and Logistics Studies, University of Sydney) and* ***Chinh Ho*** *(Institute of Transport and Logistics Studies, University of Sydney).*

Abstract

The concept of Mobility as a Service (MaaS) has recently grown in popularity with several MaaS trials and commercial products. A MaaS ecosystem typically consists of customers, transport operators, regulatory authorities, data integrators and analysts, technology and platform providers and the MaaS broker/aggregator; however, this can be extended to include ICT infrastructure providers, researchers, insurers, investors and media, passenger institutions, marketing and advertising firms. Recently, industry and academia have proposed various business models, integrating different stakeholders to operationalize the MaaS concept. Using the cases of Whim in Helsinki, Finland and Tripi in Sydney, Australia, this study investigates the importance of trust and collaboration among the stakeholders in MaaS eco-systems and unravels factors that contribute to building trust and collaboration. This study also explores the process of how the trust and collaboration among the MaaS stakeholders develops in MaaS eco-systems. The methodology involves two key phases. Phase I employs the Constructivist Grounded Theory Method using in-depth interviews with key decision makers in each case study. Phase II uses the Exploratory Factor Analysis technique. This paper focuses on Phase I and provides insights to help understanding of the importance of trust and collaboration in MaaS schemes and the factors which builds collaborative relationships focusing on the different stakeholder roles and responsibilities.

SESSION 4C: TRAFFIC MODELLING

Modelling network-wide travel time variability: A case study [96]

Neeraj Saxena *(Australian Road Research Board (ARRB)),* ***Kasun Wijayaratna*** *(UTS),* ***Kevin Wu*** *(Australian Road Research Board (ARRB)),* ***Sai Chand*** *(UNSW Sydney),* ***Aleksa Zlojutro*** *(UNSW Sydney),* ***Ian Espada*** *(SIDRA Solutions),* ***Vinayak Dixit*** *(The University of New South Wales) and* ***Charles Karl*** *(Australian Road Research Board)*

Abstract

The Australian Transport Assessment and Planning (ATAP) guidelines have been developed to assist planning, assessing, and developing transport systems and initiatives. It is widely recognised that travellers take into consideration travel time reliability in their travel decision making. Therefore, the benefits of improved travel time reliability ought to feature in appraisal of transport-related initiatives. The aim of this paper is to investigate two approaches to determine travel time variability at a network level. The first approach is a novel technique referred to as the Approximate Route Standard Deviation (ARSD) method. ARSD estimates the route travel time variability by applying a correction factor to the sum of the standard deviation values of the links forming a travel route. The second approach utilises the Strategic User Equilibrium (StrUE) traffic assignment approach to determine travel time variability given day-to-day changes in origin-destination demands and/or link capacities. This paper utilises traffic data from Sydney as a case study to demonstrate the application of ARSD and StrUE, and the results demonstrate merits and challenges pertaining to each method. The findings

from this paper can provide meaningful insights to practitioners in evaluating network-wide travel time variability benefits in a road network and utilise it in transport planning and economic appraisal applications.

Maximum queue length estimation at signalized intersections using shockwave theory and Kalman filter [46]

Wanuji Abewickrema *(University of Queensland),* ***Mehmet Yildirimoglu*** *(The University of Queensland) and* ***Jiwon Kim*** *(University of Queensland)*

Abstract

This paper proposes a combined framework of Lighthill–Whitham–Richards (LWR) shockwave theory with Kalman Filter (KF) for real time vehicular queue length estimation at signalized intersections on urban arterial roads. LWR shockwave theory was used as the base to identify traffic state changing points (e.g., capacity, jam density, free flow), which we call break points by relying on high resolution (2 seconds) traffic signal data. Once we identify the traffic state changing points, time at which these points occur can be used to reconstruct the shockwaves happening at the intersection in each signal cycle. Finally, these shockwave speeds were utilized in calculating the maximum queue length of each signal cycle. This model can identify traffic state changes that distinguish upstream arrival traffic flow from queue formation flow (jam density state). Thus, this approach can estimate time varying queue length even when the signal links are over saturated with long queues. Although shockwave theory successfully describes the complex queuing process, these models assume known vehicle inflows, which cannot be satisfied for most of situations. In our methodology we incorporate a different framework to estimate the vehicle arrivals by using 2 seconds vehicle detector data and adjacent Bluetooth detector data from the upstream intersection for real world applications. This estimation model can be applicable to scenarios when detailed "event-based" data are not available. The estimated maximum queue length has been evaluated using simulated ground truth data using AIMSUN. Evaluation results demonstrate that the proposed models can estimate long queues with satisfactory accuracy with the availability of only 2 seconds vehicle occupancy data, arrival flow and known signal timing data. Expansion to the base model is proposed using Kalman Filter (KF) to improve the reliability of the proposed model. Limitations of the proposed model are also discussed in the paper.

Tourists, visitors and urban modelling [16]

Robert Nairn *(Retired)*

Abstract

Urban travel modelling is normally based on the expected daily (or peak hour) travel of the city's residents, although trips to and from external destinations are often included. It is not normal to specifically identify the daily travel made by visitors and tourists to the city even though their travel habits are distinctly different than those of residents. Some visitors tend to prefer public transport or taxis and they travel at different times, to different sites and for different purposes than the local residents. This paper explores the problems and difficulties in attempting to identify and include visitor travel into the modelling process and attempts to assess the probable effects of doing so. It relies on a study of Canberra (in 2013) to provide a case study.

SESSION 4D: ECONOMICS

BCR: Benefit Cost Ratio or Barely Capturing Reality? [89]

Megan Roberts *(NineSquared),* ***Christine Atkins*** *(NineSquared) and* ***Anthony Vine*** *(NineSquared)*

Abstract

In this paper, we discuss some of the drawbacks of relying on one value to inform investment decisions. We discuss the need to change current appraisal guidelines to promote including a range of analysis with the underlying robustness of results clearly communicated. This often leads to impacts being excluded from analysis. We highlight the risk of relying on one result to inform investment decisions. We consider two recent examples of projects where the benefit cost ratio is not able to convey the full extent of impacts a project would bring, and a reluctance

from policy leads to attempt more innovative analysis. We then consider examples from the UK for how they present results to include analysis with different levels of robustness and a range of outcomes in results. We conclude with three recommendations. The first is that a framework is developed to allow for inclusion of less robust analysis separate to results which are based on well-established methodology. Secondly, we recommend that a range of results are presented to decision makers to reduce reliance on one value and communicate the level of uncertainty around analysis. Finally, we recommend that reliable methods for collecting data are established so that the robustness of analysis in emerging areas can be improved over time.

Valuing life when roads are increasingly safe [126]

Neil Douglas *(Douglas Economics)*

Abstract

"I guess it comes down to a simple choice, really. Get busy living or get busy dying" Andy Dufresne's choice made me think of the surveys and studies commissioned by Government over the last 30-40 years to work out the Value of Statistical Life (VOSL) which is possibly the most profound value used in economic Cost Benefit Appraisal. The New Zealand Ministry of Transport commissioned a study half a life-time ago in 1989-90 that worked out VOSL at just under $2 million; this was after half the sample was discarded for inappropriate responses. A similar survey undertaken a decade later was dismissed due to 'unresolved policy issues' and a survey in 2017 produced a value of $8.3 million but on the basis of an accident rate out by a factor of 100. Overseas experience in estimating VOSL has not been much better. That's apart from the sanguine Germans who have stuck to a straightforward Human Capital approach of valuing foregone income from premature death plus humanitarian costs which has produced a VOSL half that of New Zealand. Andy's US Government has gone for reviewing wage rate risk studies that have little to do with road accident risk but which have produced a prodigious VOSL of NZ $15 million. Canada and Transport for NSW have values much higher than New Zealand that have been mysteriously calculated by the Canadians and mercurially factored by the NSW researchers. So how much of VOSL is real as opposed to a figment of Government purpose? This paper argues that it is more the latter since VOSL has increased whilst road fatality risk has decreased. Had VOSL declined in line reducing accident risk or at least remained constant (after adjusting for inflation) it would have been more difficult to justify safer behavioural controlling initiatives. The rise in VOSL reflects Government ambition to "keep us safe" as articulated in the New Zealand Government's 'road to zero' program. A laudable ambition viewed on its own, despite being ultimately unachievable, moving closer towards it comes at a cost of higher petrol prices, higher vehicle charges, more police fines and higher taxation. Then there are the 'indirect' costs of slower travel times, greater inconvenience from extra regulations (mandatory bicycle helmets for example) and less freedom to live our lives just how we'd like. Government may help forestall our death at a largely hidden cost but as William Munny wisely muttered to the Schofield Kid "we've all got it coming, kid".

Accounting for the social benefits of regional transport investments – A case study from the Great Western Highway upgrade program [97]

Lee Jollow *(RPS) and* ***Kapil Kulkarni*** *(RPS)*

Abstract

Regional economic development is an increasing focus of government policy with regional transport investment often targeted at a broad range of social, tourism, industry, resilience and environmental benefits. However, current economic appraisal techniques for business cases focus on conventional transport benefits, which may disadvantage regional projects with lower population densities than urban areas competing for funding. A more comprehensive approach to benefit estimation is needed which adapts existing techniques from other social infrastructure sectors. This paper presents an expanded benefit framework for regional transport projects, case studies of transport-induced health and education ('human capital') benefits estimated for the Great Western Highway Upgrade Program, and an overview of UK Social Bank willingness to pay

estimates for improved social outcomes. The case studies demonstrate that the benefits are likely to be material to the investment decision. These emerging benefit estimation techniques need to be further refined and embedded in practitioner guidelines for economic appraisal and business cases so that they are given sufficient weight in investment decisions.

DEBATE: THAT SPORTS EVENTS CREATE GREAT TRANSPORT LEGACY

For many years cities have competed for the right to host major sporting events with the expectation that they will leave a legacy of urban regeneration and improved transport infrastructure, but is this expectation justified?

For the Affirmative:

- Barry Gyte, *Gyte Consulting*
- Jane Hornibrook, *Hornibrook Consulting*

For the Negative:

- Prof Matthew Burke, *Griffith University*
- Anthony Vine, *NineSquared*

SESSION 5A: DEMAND MODELLING

Can partial structural information of travel demand improve the quality of OD matrix estimates? [120]

Krishna Behara *(Queensland University of Technology) and* ***Ashish Bhaskar*** *(Queensland University of Technology)*

Abstract

The traditional upper-level formulation in the bi-level OD matrix estimation process includes link flows and is mathematically an under-determinate problem. Various methods exist in literature to improve the quality of OD estimates by using additional traffic information including target OD, traffic speeds, travel times, turning proportions, trajectories, and partial OD flows. Irrespective of the type of traffic information, this study along with a few limited studies are of the opinion that structural information of OD needs to be accounted in the upper-level formulation to improve the quality of final OD estimates. To this end, this study investigates if additional structural knowledge available through partial OD flows (referred as sub-OD flows) can improve the OD estimation quality. This study used two methods to capture the OD structure at two levels and refer to them as macro-OD and micro-OD structural information. Few studies in the past have applied the macro-OD structural information (captured using correlation coefficient) in OD estimation formulation. However, a method to account for micro-OD structure (captured using ratio of OD flows from the same origin and end into destinations with similar trip attractions) and integrate it into the upper-level objective function formulation was never developed and therefore is the major contribution of this study. The proposed methodology was demonstrated on Brisbane city network using synthetic link flows and partial OD flows from Bluetooth observations. The findings from this study revealed that exploiting the partial OD structural information through macro and micro sub-OD flows improved the quality of OD estimates better than using other candidate formulations.

Recalibrating travel demand models using Census data and household travel survey data from other jurisdictions: A case study of Greater Adelaide [100]

Ali Ardeshiri *(University of South Australia) and* ***Akshay Vij*** *(University of South Australia)*

Abstract

Travel demand models are quantitative tools that are used by local, regional and national planning organizations for the development of evidence-based transport policy. Travel demand models can offer insights on current patterns of travel behaviour and provide a framework for predicting changes in behaviour in response to changes in the transport system. Forecasts from Travel demand models are used to determine the capacity that new infrastructure must provide; and to facilitate the economic, environmental and social impact assessments of competing initiatives. Concerns are growing that diary surveys may be less viable in the future for several reasons including increasing survey costs. This has led to the intriguing question

of whether it is possible to take advantage of data from disparate sources for a region interest. The potential payoff in terms of substantial resource savings for data collection for all regions regardless of size makes this a particularly appealing avenue of development. Consequently, the objective of this study is to develop and apply a methodology for recalibrating transport demand model parameters that does not require primary data collection.

Reducing car use without changing mode [130]

Elizabeth Ampt *(Concepts of Change)*

Abstract

Many authorities in Australia and New Zealand are finding that private vehicles cause considerable problems which they would like to alleviate: contribution to climate change, congestion, decreasing community spirit, decreasing health and well-being, reduced liveability, safety concerns and so on. This has led them to set targets to achieve a reduction in car use and often also commissioning long-term programs to reduce car use. A review of examples in Australia and New Zealand suggests that programs are being limited by inappropriate definition of the targets or objectives (i.e. what is to be achieved), the way in which change should be measured (i.e. what does success look like) as well as a lack of understanding behaviours, and the principles which make behaviour easiest to change. This paper describes ways in which clearer measurable objectives can be defined and options for defining success in a way that programs and initiatives can be more clearly specified and change more easily measured – as well as achieving a greater magnitude of change.

Modelling small-area electric vehicle uptake across Australia [86]

David Mitchell *(Bureau of Infrastructure and Transport Research Economics) and* ***Robert Monterosso*** *(Bureau of Infrastructure and Transport Research Economics)*

Abstract

Electric vehicles (EVs), while presently comprising only a small fraction of all registered vehicles in Australia, are expected to increase significantly over the next several decades as manufacturers increase the range and number of EV models available. The timing and spatial distribution of future EV uptake will have implications for electricity generation capacity and the infrastructure necessary to support distribution of electricity required to meet future EV energy needs. Ensuring adequate EV charging infrastructure is available in the right places will be integral to support future EV uptake. There have been a range of studies that have investigated likely future EV uptake in Australia at national and state level, but few studies that have considered likely uptake at a more granular scale and none for the whole of Australia. This paper analyses current spatial EV uptake at small-area geographic scale across Australia, and estimates the relative importance of a range of socioeconomic variables and other relevant factors, such as EV charging infrastructure availability and installed rooftop solar generating capacity. The paper also uses the empirical results to estimate the likely future rate of EV uptake spatially across Australia. The results suggest that uptake is likely to be concentrated in higher-income and more populated areas of major capital cities. Uptake in non-urban and regional areas are likely to lag uptake in cities.

SESSION 5B: FREIGHT MODELLING / ECONOMICS

Multimodal network routing problem using Multimodal Leg Outcome (MLO) table [115]

Surya Prakash *(University of South Pacific, Fiji),* ***Russell Thompson*** *(The University of Melbourne) and* ***Chirag Prakash*** *(International School Suva)*

Abstract

Multimodal transportation is being increasingly adopted by a large number of freight companies. Multimodal transportation refers to using combinations of various transportation modes to move commodities from origin to destination. In this paper, a table is created to store the selected simulation results, which we shall refer to as a Multimodal Leg Outcome (MLO) table. This table is then utilized to find an optimal route in a multimodal network for given origin and destination. The model developed in this paper integrates total travel costs and total travel time of the routes subject to the availability of each mode for each leg, to generate the most preferred routes. Due to this model being multi-objective, where the desire is to minimise more than one objective function, we construct the MLO table using pareto optimal solutions. In our approach, Monte Carlo simulations (MCS) are used to generate random feasible routes and the results are analysed to extract the pareto optimal solutions (pareto front) offering various routes with respective advantages in terms of duration and/or costs. These pareto optimal solutions are then used to develop a Multimodal Leg Outcome (MLO) table. The proposed approach is then applied to a simple situation and the results are presented. It is shown that the MLO table obtained can be used not only to find an optimal route in the respective multimodal network, given origin and destination, but also can be utilised after altering the availability of random vertices and/or modes of transportation in the original network.

Rethinking rail freight access: developing a new policy agenda [129]

Phil Bullock *(NineSquared) and* ***Tom Frost*** *(NineSquared)*

Abstract

Road and rail freight access pricing have been challenging areas for Australian policy makers for many years. Experience from the past two decades suggests that both policy makers and industry are finding it difficult to adhere to the regimes developed to price road and rail networks. An unintended consequence of the current policy settings has been rail freight network access charges increasing significantly more quickly than road freight registration charges over a period when policy change and technology innovation have also worked improve road's competitiveness and mode share. New thinking is needed about the way that pricing and access arrangements are managed for the national rail network. This paper recommends the development of a policy agenda or action plan for reforming pricing and access arrangements for the national rail network. This could include short term actions to reduce pricing discrepancies between road and rail freight, and longer term reforms to harmonise pricing and access arrangements across the national rail network. Reforms could build upon implementation of the recently developed National Rail Action Plan (NRAP) to maximise the benefits of rail network investment planned over the next decade.

Stakeholder decisions shaping urban freight [27]

Loshaka Perera *(University of Moratuwa) and* ***Russell Thompson*** *(University of Melbourne)*

Abstract

The demand for urban freight transport is growing and the main mode of carriers is on-road freight vehicles. Due to the limited resources and prevailing constraints impeding stretching the facilities, it is essential and timely to look at ways how efficiency can be improved in the urban freight industry. Consideration of the costs and benefits to all stakeholders is important when policy decisions are

made. The acceptability of a policy by stakeholders is important and the sustainability of a policy relies upon the net benefits to each stakeholder followed by their level of acceptance. However, decision-making power in supply chains is usually limited to one dominant stakeholder and identifying such a dominant player in the supply chain is essential for policymakers. This study aims to identify the objectives and priorities of key stakeholders involved in this urban freight. Attention is paid to freight route selection, usage of toll roads and their present perception to identified conditions. The outcome from a discrete choice experiment was used to determine freight driver's willingness to pay toll charges to use toll roads in the urban context. This information is necessary for traffic assignment and no such data can be found in the literature. Overall, this study sheds light on identifying various urban freight stakeholders and what factors are prominent in their decision making processes.

SESSION 5C: BIG DATA / PAVEMENTS

Mindfulness and commuting to campus: Pilot study from Monash University [87]

Alexa Delbosc *(Monash University),* ***Craig Hassed*** *(Monash University),* ***Richard Chambers*** *(Monash University),* ***Amanda Stephens*** *(Monash University) and* ***Sjaanie Koppel*** *(Monash University)*

Abstract

Mindfulness is a state of purposeful attention, with an attitude of nonjudgment. Mindfulness can have wide-ranging benefits including: improved attention and memory, greater physical and mental health, enhanced job performance and reduced burnout. Recent work by our research team has found that mindful drivers are less aggressive, have fewer driving violations and are less likely to be distracted . The role of mindfulness in other travel modes is under researched. Given that on average, Australians spend between 3 and 4 hours per week commuting, it is worth exploring the interaction between commute mode and mindfulness. The aim of this pilot study was to explore the potential relationship between mindfulness, commute mode, and behaviours undertaken while commuting. The study was conducted among staff and students at Monash University. We found significant differences in mindfulness depending on which mode people used to commute and what activities they undertook while travelling. The findings provide support to further explore the potential relationships between travel and mindfulness.

A data-driven approach to benchmark route choice 1 set generation algorithms [107]

Raghav Malhotra *(Queensland University of Technology),* ***Chintan Advani*** *(Queensland University of Technology) and* ***Ashish Bhaskar*** *(Queensland University of Technology)*

Abstract

Route choice set is an essential input for the traffic assignment process. Several path generation methods exist in literature, the quality of which rely on the principle governing the algorithm and its input parameters. Accordingly, it's hard to choose the algorithm for the practical implementation. This study benchmarks these algorithms by providing a qualitative and quantitative comparison among the prominent path generation algorithms in the literature. The algorithms are tested for an OD pair on real Brisbane network, the results of which suggest that the simulation method outperforms the other algorithm.

A comparison study of different data resolutions for deep reinforcement learning based adaptive traffic signal control system [59]

Mobin Yazdani *(University of Melbourne),* ***Majid Sarvi*** *(University of Melbourne) and* ***Saeed Asadi Bagloee*** *(University of Melbourne)*

Abstract

By recent advances in technology and Artificial Intelligence (AI), traffic signal control systems are preferably designed to have intelligence rather than rule-based structure. Deep Reinforcement Learning (RL) as a solution for sequential decision-making problems has been extensively used for adaptive traffic signal control (ATSC) systems. The deep RL-based ATSC systems have shown promising results

versus current actuated (rule-based) ATSC systems. The conducted studies have employed different data resolutions either collected in vehicular network (e.g., location and speed of individual vehicles) or from camera devices (e.g., queue length, density, average speed) for proposed models. However, the impact of different data resolutions on deep RL-based ATSC systems training performance has not been studied yet. In this study, we compare the three different data resolutions in terms of computation time, training stability and results for variety of performance measurements. The Double Deep Q-Network (DDQN) algorithm is utilized as our intelligent agent. To test and evaluate the different data resolutions, a real isolated intersection is modelled in a simulation environment with real traffic volume demand. The experimental results have shown that vehicular network high resolution data can only contribute to a slight improvement versus camera data in terms of reduction in travel time, queue length etc. at the expense of more computation time in training models. Also, the camera data is more accessible compared to vehicular network data which needs sensors on plenty of vehicles in network. Hence, we recommend using camera data which provides aggregated but adequate data for deep RL-based ATSC models.

Impacts of autonomous vehicles on road and pavement design [113]

Son Pham *(La Trobe University),* ***Long Truong*** *(La Trobe University) and* ***Nhu Nguyen*** *(Deakin University)*

Abstract

This paper aims to investigate the impacts of autonomous vehicles (AVs) on road geometric and pavement design by modifying Austroads' design guides. Results showed that a fleet of fully AVs had lower geometric design requirements, i.e., shorter stopping sight distance, shorter vertical crest curve and sag curve. This suggests not only significant cost reductions in building new roads for AVs, but also speed increases on existing roads from a geometric design perspective. Results also confirm that AVs can better utilise pavement structure as the same pavement structure can withstand much higher AV traffic loading than HV traffic loading. In other words, given the same traffic loading, pavement thickness could be reduced for AVs. Overall, the findings of this paper suggest AVs can lead to better utilisation of existing road infrastructure.

SESSION 5D: COVID

The implications of working-from-home for transportation: literature review [83]

Long Vo *(PATREC, University Western Australia),* ***Brett Smith*** *(PATREC, University Western Australia) and* ***Sharon Biermann*** *(PATREC, University Western Australia)*

Abstract

The drastic social distancing and travel restriction measures imposed during the COVID-19 pandemic resemble a large-scale natural experiment on the changes of travelling behaviour and adaptation in the presence of an unexpected health shock. In this paper several opportunities and challenges of working-from-home (WFH) practices are discussed; with a focus on the reduction of travel demand and pressure on constrained transport networks. Findings for Australia indicate the combined effects of heightened concern related to public transport hygiene, vehicle capacity limits complying with social-distancing requirements, and a generally positive experience associated with WFH are expected to lead to a higher level of WFH compared with pre-pandemic levels.

The impact of COVID-19 pandemic on parcel delivery pattern in Sydney [67]

Masoud Kahalimoghadam *(The University of Melbourne),* ***Michael Stokoe*** *(Transport for NSW),* ***Russell G. Thompson*** *(The University of Melbourne) and* ***Abbas Rajabifard*** *(The University of Melbourne)*

Abstract

The COVID-19 pandemic has changed the goods distribution patterns for both Business to Business (B2B) and Business to Customer (B2C) segments. This paper investigates the pandemic impacts on B2B and B2C parcel delivery changes in the Sydney metropolitan area. For this purpose, initially, the

spatial pattern of the parcel delivery in 2020 has been compared with that of 2019 (before the pandemic) using GIS software. Based on this analysis, a significant reduction in parcels and freight deliveries to the CBD has happened during the lockdown, while the inner and outer metropolitan areas have experienced higher demand for parcel deliveries. After defining metropolitan areas with significant demand changes, major factors were identified that have contributed to the pattern. The changes are correlated with employment, internet access, and population factors. The results will support logistics stakeholders in their future practice of mitigation and disaster preparedness actions for pandemics.

Lockdowns and lags: Lessons from the effect of COVID-19 on the Perth transportation system [125]

Tristan W. Reed *(Curtin University) and* ***Sharon Biermann*** *(University of Western Australia)*

Abstract

The COVID-19 pandemic has changed travel demand throughout the world as cities are locked down and new ways of working have been adopted to mitigate the effects of the pandemic. While Perth and Australia more generally have fared better than most places around the world, changes in mode choice and demand have been observed within Perth from traffic count and smartcard usage data. This has been especially notable during 'lockdown' periods where residents were required to stay home. More importantly, over the year since the pandemic has begun, the "between lockdown" periods offer unique insights into possible longer term effects which could be perpetuated into the future, with ongoing consequences for deferring or avoiding the need for transport system infrastructure. While previous studies have reported on overall changes in vehicle traffic and public transport volumes across cities as a whole, this study considers spatial trends for different parts of the city in order to differentiate changes in travel to and from the city centre from cross-city travel in inner and outer suburbs of differing types. This has been gleaned from various traffic counting sites throughout Perth alongside an analysis over time of the public transport smart card boardings and alightings between 'catchment areas' for various lines throughout Perth. Indications are that recovery is quicker for shorter lockdowns and to higher levels within inner-city areas with spatial differences suggesting changes in recovery depend also on socio-economic context.

SESSION 6A: SOCIAL/ECONOMIC

Planning with Country: Has the transport profession begun the journey? [64]

Eric Keys *(Eric Keys & Associates) and* ***David Week*** *(Assai Consult)*

Abstract

This paper makes a call to action for transport planners to advance the profession's journey on the road to reconciliation with the Indigenous peoples of Australia. We provide evidence that transport planners have scarcely begun this journey. We frame this call as a call to innovation, similar to challenges the profession has met in the past, rather than a matter of compliance. The paper advances two reasons for taking this journey. The first is a social responsibility both to the nation, and to the transport planners' primary clients: government. Both have engaged on this journey. The second is pragmatic: to avoid excessive delays and additional costs to projects on country, when those projects are challenged by the Indigenous people whose country is impacted. The paper presents two cases of the latter. Finally, the paper sets out some basic tools and understanding for this journey as a relationship between two cultures—settler and Indigenous—which requires reflection, engagement and dialogue, because of the deep cultural nature of the change required. Finally, following the lead of the Federal Government in light of poor progress of 'Closing the Gap' we recommend co-design as the way forward.

Age, transport, and technology: Older Queenslanders' travel behaviours and use of transport-related technology [66]

Kelly Bertolaccini *(Griffith University) and* ***Mark Hickman*** *(University of Queensland)*

Abstract

As Queensland's population ages, the state's transport system will need to adapt and become more age friendly. To better understand the transport behaviours and transport-related technology use of older Queenslanders, we conducted 12 focus group discussions across the state, including in regional and remote areas. The transcripts of these discussions were analysed by our research team to determine common themes. We found that while transport is difficult for non-driving seniors across the state, transport is particularly difficult for older Queenslanders living in remote locations and secondary cities due to multiple issues: the long distances they must travel for services, limited transport options, and fewer younger people to offer rides to aging community members. We also found that available door-to-door transport services for non-driving seniors are not meeting current demand. Finally, we found widespread distrust of mobile applications and cashless payment among even the most tech savvy seniors, suggesting new and emerging transport modes which rely on these methods will exclude rather than help older Queenslanders.

Exploring a social Licence to operate the road system [22]

William Young *(Monash University),* ***Michael Shackleton*** *(ARRB) and* ***Sareh Bahrololoom*** *(Monash University).*

Abstract

It is generally considered that the transport system needs the support and engagement of the public in its development and implementation. This paper looks at an approach for gaining insight into how the community views the performance of the road transport system. It explores the concept of the Social Licence to Operate the Road System (SLORS) and shows how it can be applied to road policy and network considerations. The paper looks at 18 policy issues and identifies how these can be placed into a SLORS framework. The policy issues are categorised as falling into 5 zones: User Advocacy Zone, Support Zone, Equilibrium Zone, Tolerance Zone and Opposition Zone. The zone the issue falls into provides information to policy makers on the public's view of the policy. For instance: in the Advocacy zone issues like Driver behaviour should improve, Roads must be safe for all users, the Physical quality of the road and their surface should improve, and Road travel should be more environmentally sustainable in the future are supported. In the Opposition zone People paying a toll or road charge for each trip, Private companies having a large role in planning and management of roads, increased congestion and increased traffic on our roads in the future receive less support. This information can assist in pointing the policy maker in the best direction to get the policy supported. The paper closes with some indications of further work with the SLORS.

SESSION 6B: SAFETY

A conceptual approach towards the evaluation of the vulnerability of urban railway network infrastructure by analysing railway accident reports [31]

Wei-Ting Hong *(The university of Sydney),* ***Geoffrey Clifton*** *(The university of Sydney) and* ***John Nelson*** *(The university of Sydney)*

Abstract

Analysis of the vulnerability of urban rail transport systems has received considerable attention in the literature over several decades. Since economic development is usually associated with increasing demand for railway transport as more and more passengers rely on railways, disruptions to the railway system become unaffordable and create a significant impact on society and economies. Hence, there is a growing need for accurate estimations of railway transport vulnerability and effective mitigation strategies. This thesis aims to shed new light on extending the knowledge on the vulnerability of the railway system by exploring the

underlying hazards and building a rigorous model by applying state-of-the-art techniques. A railway accident report dataset is created, retrieved from the website of official railway accident investigation bodies. An ontology will be introduced to describe the nature of the railway accidents and provide a solid framework to extract data from original reports written by railway accident investigation bodies in selected countries. To recognize the valid entities in the original reports automatically, Natural Language Processing (NLP) will be utilised and several NLP tasks are designed to reach our objectives. By developing a comprehensive and extendable model for the analysis of railway accidents reports, the improvement on railway safety and vulnerability is expected to be significant.

On the transferability of traffic conflict-based safety assessment methods: A case of crash frequency-by-severity prediction models [29]

Ashutosh Arun *(Queensland University of Technology) and* ***Md Mazharul Haque*** *(Queensland Unversity of Technology)*

Abstract

Traffic conflict techniques for road safety assessments are becoming popular in recent years. However, the traffic conflict-based methods lag behind crash-based safety evaluation methods in transferability, which refers to applying the developed crash prediction models of a set of sites to a new external site. This study specifically investigates whether the multivariate peak-over-threshold extreme value model for estimating crash frequency-by-severity levels developed in a previous study to two signalised intersections in Southeast Queensland. The study uses two transferability approaches, namely, an application-based approach with an uncalibrated model and an estimation-based approach, the latter involving calibration of conflict thresholds of negated modified time-to-collision and delta-v indicators using local data. The study found the latter approach to provide more accurate crash estimation results and recommends it for future research in this direction.

Dynamic assessment of regulation and policy framework in the cybersecurity of connected and autonomous vehicles [124]

Shah Khalid Khan *(School of Engineering, RMIT University Carlton VIC 3053, Australia),* ***Nirajan Shiwakoti*** *(School of Engineering, RMIT University Carlton VIC 3053, Australia),* ***Peter Stasinopoulos*** *(School of Engineering, RMIT University Carlton VIC 3053 Australia) and* ***Matthew Warren*** *(RMIT Centre for Cyber Security Research and Innovation, RMIT University)*

Abstract

CAVs (Connected and Autonomous Vehicles) technology will transform the current Intelligent Transportation System (ITS). However, the most significant challenge is keeping up the criminal justice system, particularly the Regulation and Policy Framework (R&PF) in ITS, because ubiquitous CAVs connectivity expands the scope of criminal activity in both the physical and cyberspace realms. This article developed a Causal Loop Diagram-based System Dynamic model that incorporates critical inter-disciplinary parameters and dynamically evaluates the impact of R&PF on CAVs cybersecurity. Two loops are envisioned: “balancing loops” demonstrate how R&PF can facilitate cyber-attacks prevention, whereas “reinforcing loops” reveal how imposing R&FP can negate its potential benefits by creating a detrimental parallel circle. Based on the feedback loops, a “shifting the burden” system archetype is postulated in which governments combat cyber-threats by strengthening R&PF while also reducing CAVs adaptation through imitation and induction. Recommendations for R&PF formulation include a balanced approach to the trade-off between: i) protection of CAV users’ privacy and freedom, ii) operational and data accessibility constraints on CAV automakers and service providers, as well as their business investment protection, and iii) state regulators command and control thresholds.

SESSION 6C: NEW TECHNOLOGY

The potential impact of informational cues on willingness-to-pay for driverless cars [20]

Milad Ghasri *(The University of New South Wales) and* ***Akshay Vij*** *(University of South Australia)*

Abstract

This study investigates the impact from informational cues on willingness-to-pay (WTP) for autonomous vehicles (AVs). The studied informational cues comprise social media and mass media sentiments, market penetration, and word-of-mouth from social contacts. The effect of word-of-mouth from social contacts is adjusted according to the trust associated with the social contacts. It is argued that informational cues affect AV consideration which in turn exerts influence on preferences towards AVs. A behavioural framework is proposed to link informational cues to AV consideration, and to model AV selection and AV purchase as a function of AV consideration. The parameters of the model are estimated using a representative sample comprising 862 residents from Sydney, Australia. A latent class approach is used to capture heterogeneity in the sample. Thanks to the novel structure of the proposed behavioural framework, WTP for automation is estimated based on the status of informational cues. According to the results, one per cent increment in market penetration will increase WTP by $650; and one per cent increment in the mass media and social media sentiments will increase marginalised WTP by $398 and $219, respectively. The impact from word-of-mouth depends on the trust associated with social contacts. For an average-trusted social contact, a negative recommendation from the contact will reduce WTP by $13,399 or $5,290, and a positive recommendation will increase WTP by $8,099 or $14,080 depending on whether the social contact is an AV-owner or not. Finally, our framework offers new insights on the dynamics of innovation diffusion, and the timing of policy interventions seeking to incentivise innovation uptake. In general, when informational cues are positive, policy interventions are only needed in the very early stages of diffusion. Once market penetration has crossed a critical threshold, it generates sufficient confirmatory signal to persuade more customers to adopt the innovation, the policy interventions can be withdrawn, and the diffusion process becomes self-sustaining. However, if signals from informational cues are not positive enough, strong policy support is needed to sustain the diffusion process.

Framework for field evaluation of signal cooperative intelligent transport system use cases as based on the Ipswich Connected Vehicle Pilot [91]

Joshua Elder *(Queensland University of Technology),* ***David Sulejic*** *(Queensland Department of Transport and Main Roads),* ***Geoffrey McDonald*** *(Queensland Department of Transport and Main Roads) and* ***Ashish Bhaskar*** *(Queensland University of Technology)*

Abstract

Cooperative Intelligent Transport Systems (C-ITS) have the potential to greatly increase traffic safety on roads. To ensure C-ITS implementation is effective, the equipment within the ecosystem must communicate using standardised, available and reliable messages that can be trusted for use in end-user warnings. If the warnings displayed to the end-user are incorrect, untimely or inappropriate the system may have the reverse effect on user safety instead. Queensland Department of Transport and Main Roads (TMR) identified the need for government investment in C-ITS roadside stations (R-ITS-S) and through the Cooperative and Automated Vehicle Initiative's (CAVI) Ipswich Connected Vehicle Pilot (ICVP) installed and studied the performance of the equipment as part of a larger behavioural study. This paper describes a framework created for the assessment of R-ITS-S suitability against ten key criteria, with a focus on reuse in future Australian deployments of C-ITS, projects and pilots. These criteria were proposed after reviewing current literature of European and U.S standards and guidelines. The assessment criteria within the framework includes: 1) Roadside Coverage – the effective range of the roadside unit (RSU); 2) Availability –the percentage of time the RSU and its substituent components are operational; 3) Reliability – a sub-category of availability, finding the Mean-Time-Between-Failures (MTBF), Mean-Time-To-Repair (MTTR) and the total number of failures; 4)

Latency –the total time for communicating messages between sent and received timestamps; 5) Usability – the accuracy of the MAP Extended Message (MAPEM) file transmitted by the RSU with respect to the road centreline; 6) Security – the percent of security certificates that fail under conditions where it is expected that certificates should be passed; 7) Refreshment Rate – the assessment of updated signal statuses between the field processor and RSU; 8) Classification Correctness – the assessment of how correct the presented signal use case messages are; 9) Integrity – the assessment of instances where the integrity of the system is compromised; and 10) Conformance – a judgement of the conformance of the ICVP against the European standards.

Planning for the electrification of Australasian road transport [26]

Tim Brooker *(EMM Consulting) and* ***Stephen Bargwanna*** *(SGB Advisory)*

Abstract

Many people and government leaders in Australasia think Electric Vehicles (EVs) are a novelty and unlikely to catch on in the near future, due to either the limited choice of vehicles available for sale, their higher cost and the typical current limits on EV travel distance between battery charging requirements. Nevertheless, there is an emerging inevitability of a much more rapid take-up of EVs over the next decade, based on international regulatory and industry trends. This paper examines some global and local planning and research considerations to address this. The research, development and commercialisation of EVs and associated components, especially batteries, is occurring globally at a rapid pace, in the major vehicle manufacturing nations of Europe, North America, China, South Korea and Japan. The quickly evolving new vehicle markets in these countries incorporate quantum leaps in new vehicle technologies and related social change, including more rapid adoption of the separate but related technology of driverless vehicles. There is much research required to follow the implications of electrification of Australasian road transport. The new vehicles and technologies are being unveiled around the world on a regular basis and the battle for market share and dominance is well underway. The Australasian public has already shown its willingness to adopt new EV related technologies. We have the largest domestic take up of solar roof installations in the world. People are buying electric bikes and personal mobility EVs in big numbers. The Australian mining sector is investing widely in deposits essential to the future EV transition like lithium, cobalt and copper.

SESSION 6D: HISTORY

Australian transport planning in the 1970's [14]

Robert Nairn *(Retired)*

Abstract

This paper discusses the changes in facilities and innovative practises in transportation planning and the changes in Federal Government attitudes that took place in the 1970's. It discusses several of the transport conferences and studies in which these changes took place and which had an enduring influence on the growth of transportation planning administration and technology in Australia. Following the 1950s post-war boom, Australian cities were growing rapidly and becoming sufficiently congested that, by the late 1960s, there was increasing academic and public interest in town planning issues, partly due to increasing perception that higher rise developments were creating "slums" and there seemed to be no alternative to increasing "urban sprawl". The role of freeways was being questioned and the debate between private and public transport was vigorous but the growing subsidies required for transit services was also causing concern. By 1970 the first round of major capital city urban transportation studies in Brisbane, Hobart, Adelaide, and Perth had been completed and Melbourne neared completion. The last of these studies was about to commence in Sydney in 1971. The Federal government began to take a greater interest and involvement in the funding of National Roads and in the planning and the value of roads in the capital cities. This Federal interest was further extended into urban development and culminated in the growth centre experiment intended to relieve population growth pressures

on the major cities. While interest eventually dissipated in this experiment, the lessons learned at this time and in the continued growth of Canberra illustrate the valuable role of early and interactive transport planning and in the degree of government commitment and intervention needed to reduce the growing problems in the major cities.

Lies, damned lies and statistics [21]

Alex Wardrop *(Independent railway operations researcher)*

Abstract

This paper tracks the historical growth of Sydney's and Melbourne's world-size suburban passenger railways from Federation to the current day prior to the COVID-19 pandemic. At the turn of the 20th Century the carriage of suburban passengers was commercially attractive since most of their patronage was attracted to each city's growing CBDs. Their patronage growth and average trip lengths prompted electrification during Australia's first heroic age between Federation and the Great Depression. Even so, they were still dominated by each city's tram networks. After performing heroically during WWII, their patronage stagnated and then declined in response to the growth in private vehicular travel. Furthermore, they became a drag on railway finances. Patronage did not grow again until signature infrastructure projects were completed and traffic congestion made them more attractive to commuters, who now constituted two-thirds of their patronage. They were also now attracting commuters who are not travelling to their CBDs. Furthermore, peak hour trains were becoming more crowded than they were immediately prior to WWII. Unfortunately, the COVID-19 pandemic has now stymied the progressive growth in suburban railway patronage.

Evolution of Sydney's bus network: 1925 to 2020 [99]

Hema Rayaprolu *(The University of Sydney) and* ***David Levinson*** *(The University of Sydney)*

Abstract

Studies of bus network evolution are less common because unlike roads and railways, bus networks lend themselves to frequent modifications which are rarely archived. But an understanding of the dynamics of bus network evolution is invaluable as their flexibility enables planners to tailor services to suit a region's characteristics. Our research leverages archived information on Sydney's bus route modifications and timetables to investigate the evolution of the region's bus network over nearly a century, from 1925 to 2020, with a motivation to inform future public transport planning decisions. The extended abstract describes the procedure employed in converting historic archives into a state-of-the-art spatio-temporal database. Preliminary results from a network structure analysis of the historic bus networks are also presented.

ABSTRACTS
FRIDAY 10 DECEMBER 2021

SESSION 7A: DEMAND MODELLING / SAFETY

Can a metaheuristic be used to assist in discrete choice modelling? [104]

Prithvi Bhat Beeramoole *(QUT),* ***Alexander Paz*** *(QUT),* ***Md. Mazharul Haque*** *(QUT) and* ***Alban Pinz*** *(Queensland Department of Transport and Main Roads)*

Abstract

Currently, the estimation of discrete choice models rely on experience, knowledge of the problem context, and statistics to make critical modelling decisions. In addition, ad hoc procedures that can be time-consuming and prone to human bias are frequently used to improve specifications. As a result, restricted specifications are often adopted due to which important insights and hidden behavioral patterns can be overlooked. Considering the large number of decisions that advanced discrete choice models involve, a metaheuristic-based framework is proposed to assist in discovering and testing meaningful specifications. The framework involves an unbiased but constrained and efficient search process. A numerical experiment is conducted to illustrate the efficacy of the proposed approach in terms of interpretability and model fit. The proposed framework would benefit as a decision-assistance tool in applications involving a large number of variables and outcomes such as crash analysis and integrated land-use and travel choice models. In addition, effective policy analysis could be ensured by a substantial reduction in misspecifications that could be caused by human bias.

Analysis of head-on heavy vehicle crashes in queensland using correlated random parameters with heterogeneity in means and lindley [132]

Krishna Behara *(Queensland University of Technology),* ***Yasir Ali*** *(Queensland University of Technology),* ***Alexander Paz*** *(Queensland University of Technology) and* ***Owen Arndt*** *(Queensland Department of Transport and Main Roads)*

Abstract

Recent literature on road safety research has focussed on variants of random parameters models to capture unobserved heterogeneity that may influence the occurrence of crashes. Among such models, correlated random parameters with heterogeneity in means has recently provided better results and has become popular. However, this study illustrates a potential limitation regarding the use of correlated random parameter models without explicitly factoring for excessive zeros. To address this limitation, correlated random parameters with heterogeneity in means and a Lindley distribution is introduced in this study. These parameters factor for the unobserved heterogeneity using additional variables, correlation (if exists) across the random parameters, and site-specific variation from excessive zero crash observations.

Crash risks during mandatory lane-changing manoeuvres in a connected environment [39]

Yasir Ali *(Queensland University of Technology),* ***Md. Mazharul Haque*** *(Queensland University of Technology) and* ***Zuduo Zheng*** *(The University of Queensland)*

Abstract

A connected environment offers 360^0 awareness of hazards and situations that drivers cannot foresee. Such information (or awareness) will substantially change how humans drive and can help in solving massive road transport issues in traffic congestion,

road safety, energy consumption, and greenhouse gas emissions. More specifically, driving aids provided by a connected environment are expected to assist during the lane-changing decision-making process, which affects traffic flow characteristics and traffic safety. For instance, in 2019, lane-changing crashes accounted for about 3% of the total crashes in Queensland, Australia. Besides safety, lane-changing has been frequently reported to link with capacity drops. Recognising such profound effects of lane-changing on both traffic flow characteristics and traffic safety, there is a growing interest from researchers in understanding, analysing, and modelling lane-changing behaviour. Lane-changing is often classified as mandatory lane-changing and discretionary lane-changing. While the former refers to the compulsory nature of lane-changing that must be performed to reach a planned destination (e.g., entering and exiting a motorway, etc.), the latter is mainly performed to gain better driving conditions (e.g., speed gain, avoiding a slow-moving truck, etc.). Mandatory lane-changing generally poses a greater risk on traffic, and thus, this study focusses on mandatory lane-changing. A mandatory lane-changing manoeuvre requires a driver to maintain a safe gap in the current lane, properly judge the positions and speeds of surrounding vehicles in the target lane, and efficiently communicate the lane-changing intention with other drivers. These altogether elevate mental pressure and make the lane-changing decision-making process more error-prone, thereby increasing crash risk. To this end, driving aids provided by a connected vehicle environment could be beneficial in reducing mental workload and uncertainty associated with mandatory lane-changing. More specifically, a driver would be assisted with information about driving conditions in the current lane and surrounding traffic information in the target lane, which can minimise crash risk during mandatory lane-changing. Many studies have shown the effectiveness of a connected environment at an individual driver level and at a network level, evidence of the efficacy of a connected environment in minimising crash risk during mandatory lane-changing is scant, primarily because unavailability of crash data (which accrue slowly) in a connected environment. Given the paucity of crash data in a connected environment, this study aims to evaluate the safety benefits in terms of quantifying the crash risk by utilising more frequent (or observable) events and applying traffic conflict techniques that can provide information on the likelihood of crash occurrence, as elaborated below. In particular, a Block Maxima (BM) approach, corresponding to Generalised Extreme Value distribution, is adopted herein (to estimate and compare crash risk during mandatory lane-changing manoeuvres using the trajectory data obtained from an advanced driving simulator experiment.

SESSION 7B: NEW TECHNOLOGY

Can MaaS change users' travel behaviour to deliver commercial and societal outcomes? [30]

Chinh Ho *(The University of Sydney)*

Abstract

Mobility as a Service, or MaaS, is a relatively new business model that aims to disrupt the passenger transport industry by integrating existing mobility services into an intuitive smartphone app that allows everyday travellers to search, book, use, and pay for all their transport needs. In a fully integrated ecosystem, MaaS is envisaged to integrate not only travel information and payment, but also mobility services and societal goals to obtain the so-called four levels of MaaS integration. This paper describes the strategies used in the Sydney MaaS trial to obtain all four levels of integration and empirically assess the prospects of having a commercially viable and environmentally sustainable MaaS. Leveraging empirical data collected by GPS-tracking technology, ticketing management systems, and survey questionnaires over the five-month in-field trial of MaaS in Sydney, this paper develops a discrete-continuous modelling system to quantify, for the first time, the impacts of MaaS on users' travel behaviour and extra volume/revenue for shared modes. Based on the quantitative evidence obtained, the paper suggests a new commercial model for MaaS and identifies the likely opportunities and challenges faced by MaaS integrators.

The commercial viability of Mobility-as-a-Service (MaaS): What's in it for existing transport operators, and why should governments intervene? [111]

Akshay Vij *(University of South Australia) and* ***Stefanie Du¨hr*** *(University of South Australia)*

Abstract

Mobility-as-a-Service (MaaS) platforms offer consumers access to multiple transport modes and services, owned and/or operated by different mobility service providers, through an integrated digital platform for planning, booking and payment. Different transport operators can choose to offer their services on the platform, and the platform provider has to broker individual deals with different transport operators on a case-by-case basis. The success of any MaaS platform will depend on the platform provider's ability to persuade as many individual transport operators as possible to join their platform, to increase value to potential customers. This study examines the commercial value proposition of MaaS from the perspective of existing transport operators. We provide a comprehensive review of the international academic literature and practice examples on emerging MaaS models, and present novel empirical data for New South Wales, Australia based on interviews with over 60 national and international actors across the entire MaaS ecosystem, and additional workshops with policy stakeholders. We find that transport operators might benefit from MaaS through possible changes in their cost structures and revenue streams. MaaS could help strengthen potentially complementary relationships between services; allow operators to expand their customer base and reach newer markets; and increase asset utilisation through better matching between supply and demand. However, MaaS also poses a potential risk to existing service providers, as integration with possibly substitutive services could undermine profitability and cost recovery. In many cases, similar benefits could be realised through information and communication technologies that would not require integration with other services. Consequently, if left to the market, integration between operators is likely to be piecemeal and ad-hoc. Moreover, emerging business models bear the risk of resulting in negative societal outcomes and monopolisation trends. This, alongside the opportunities that MaaS can offer to help achieve broader societal goals, presents a strong case for an active role for governments in the development, operation and regulation of MaaS to deliver on the vision of a fully integrated transport system.

The prospects for tourism-focused MaaS in Queensland [128]

Abraham Leung *(Cities Research Institute, Griffith University) and* ***Matthew Burke*** *(Cities Research Institute, Griffith University)*

Abstract

Transport is one of the key enablers of tourism development and growth. The emerging innovations in tourism transport include micromobility (small, lightweight devices such as electric scooters or bicycles) and microtransit (on-demand and flexible public transport). These can be integrated using Mobility as a Service (MaaS) by platform to provide user-centric and seamless intermodal access with "bundled" payment options. MaaS also has great potential to improve connectivity and enhance tourism experiences, benefitting the environment and reducing congestion in tourist destinations. This paper presents a new agenda for innovating tourism in regional Queensland cities by introducing MaaS solutions. The analysis is informed by stakeholder interviews (n=20) and regional case analyses of three study areas. The results indicate a tourism-focused MaaS platform is recommended with higher priority for Townsville as the city is more ready with a greater offering of transport options to be integrated. A potential MaaS trial for tourism users to test choice bundles and integration with tourism events and attractions could provide useful data for Queensland's MaaS rollout. Eventually, a broader spectrum MaaS could emerge, including both transport and non-transport (dining, attractions and event) offerings, and this can expand into more tourism cities, be it regional or metropolitan in Queensland and beyond.

Do trackless trams need stronger roads? – the "weight" of evidence [80]

James Reynolds *(Monash University),* ***David Pham*** *(Monash University) and* ***Graham Currie*** *(Institute of Transport Studies Monash University)*

Abstract

Trackless Trams are a new generation of advanced bus technologies with significant potential for application as a cost-effective alternative to Light Rail Transit. They have significantly lower estimated construction and infrastructure costs (-62% to -82%) compared to Light Rail since they can use existing roads and don't need expensive rail tracks. However, they are very heavy vehicles that have the potential to cause pavement damage, suggesting a need for road strengthening works. The manufacturer claims they can be used on any road without the need for road pavement treatments and, because of this, can be implemented in only a few days. This paper explores the road pavement impacts of new Trackless Tram bus technologies. It finds Trackless Trams weigh between 32 and 85 Tonnes and would be amongst the heaviest vehicles used on roads. An independent inspection of existing Trackless Tram sites is reported in the paper. This discovered evidence of road pavement damage, suggesting that claims for a 'weekend' system construction period using existing road pavements are very optimistic. Modelling of road pavement performance suggests Trackless Trams are likely to require significant road pavement strengthening under almost all scenarios modelled. The traffic load bearing impact of Trackless Trams is between 14 and 221 times higher than common loads on even high traffic urban roads. Under almost all scenarios modelled, stronger pavements were needed, particularly for flexible pavements with poor quality subgrade. Larger and heavy Trackless Tram vehicles require stronger road pavement designs and for even the smaller three-module Trackless Tram on flexible pavements at light load levels, a more frequent service will require a 9.5% increase in pavement thickness compared to a lower frequency service. Implications of the research for future research and practice are discussed.

SESSION 7C: COVID

Pandemics and urban travel – Lessons for COVID-19 from the 1918-1920 Spanish flu [73]

Graham Currie *(Public Transport Research Group, Monash University),* ***Yunhao Xu*** *(Public Transport Research Group, Monash University) and* ***James Reynolds*** *(Public Transport Research Group, Monash University)*

Abstract

This paper contrasts the Spanish Flu and COVID-19 pandemics and how they impacted travel in Australian/United States cities to identify lessons learned for a better COVID-19 recovery. The paper focusses on public transport ridership impacts and explores infection rates, health and transport policy responses in both countries. The Spanish Flu (1918-1920) infected more people (broadly a third of the world's population) and was substantially larger than COVID-19 has been to date. In the US, a 2.5 times larger population share was infected by the Spanish Flu compared to COVID-19, while in Australia this ratio is over 300 times. Australian infection and mortality rates for both pandemics were substantially lower than the United States. For the Spanish Flu, this appears to result from a later arrival date of infection, during a less aggressive wave. For COVID-19, Australia has been widely acknowledged to have had a more effective health policy response based on a 'Crush and Contain' strategy, tight lockdowns, stay at home orders and a much higher public trust in, and adherence to, government responses. Australian and US approaches to mitigation of the Spanish Flu were broadly similar though neither were successful at containing the pandemic. Australia may have had a more successful border quarantine system than the US, though it was still not very effective. Substantial differences in public transport ridership trends have been found between the two pandemics. COVID-19 reduced ridership in both Australia and the US to around 30% of pre-pandemic levels. Impacts of the Spanish Flu involve much smaller declines in ridership in selected years of the pandemic in the United States and some growth in ridership. Virtually no ridership declines were found at all in Australia during the Spanish Flu as ridership on public transport instead increased during the pandemic. Lessons for transport and health policy are also identified, as are areas for future research.

How does the built environment shape active travel during COVID-19 travel restrictions? Evidence from Melbourne [42]

Mahsa Naseri *(Monash University),* ***Alexa Delbosc*** *(Monash University) and* ***Liton Kamruzzaman*** *(Monash University)*

Abstract

COVID-19 restrictions impose significant changes on human mobility patterns, with some studies finding significant shifts in walking and cycling in some cities. However, to date there is little understanding on how the neighbourhood-level built environment influenced active travel behaviour during the COVID-19 restrictions. We aimed to answer this question by examining recreational walking and cycling during different stages of lockdown in Melbourne, Australia. We compared self-reported changes in active travel data from 1344 respondents between pre- and two different stages in lockdown by various built environment factors of their residential neighbourhoods. We found that walking and cycling declined significantly during the two stages of lockdown in general. However, the mobility decline was slower in neighbourhoods with a high level of green spaces, residential area, and residential density. This is particularly true for the regular cyclist and walkers. The findings suggest the need for an equity in the design of the built environment to maintain/promote active transport.

Implications of remote working for commute travel patterns in Australia [112]

Akshay Vij *(University of South Australia),* ***Flavio Souza*** *(Afterpay),* ***Helen Barrie*** *(University of South Australia),* ***V. Anilan*** *(University of South Australia) and* ***Ilke Onur*** *(Flinders University)*

Abstract

This study assesses the viability of remote working across different industries and occupations; measures potential impacts of remote working on commute patterns; and identifies implications of changes in transport demand for the supply of transport infrastructure in urban areas. Data for our analysis comes from a nationwide survey of 2,694 employees across the 17 largest urban areas in Australia. We estimate that roughly 38 per cent of employees working in these urban areas believe that some of their jobs tasks and activities could be done remotely. Ability to work remotely tends to be highest across white-collar sectors and occupations. If these employees were able to work remotely, when possible, we estimate that this could reduce weekday commute travel by car by 12-17 per cent and by public transport by 22-31 per cent across large urban areas. Reductions in travel are likely to be greatest on Mondays and Fridays, and for commute trips made to workplaces in CBD locations. Remote working arrangements could additionally move roughly 5 per cent of commute trips outside the morning peak period, and 10-20 per cent of commute trips outside the evening peak period.

Changing work Practices, active travel, health and well-being during a pandemic [134]

Stephen Greaves *(University of Sydney),* ***Matthew Beck*** *(University of Sydney),* ***Melanie Crane*** *(The University of Sydney) and* ***Alec Cobbold*** *(University of Sydney)*

Extended Abstract

1.Introduction

Of the myriad of societal impacts of the COVID-19 pandemic, the acceleration of remote working practices, particularly working from home (WfH) has been among the most pronounced. Prior to COVID-19 restrictions beginning in March, 2020, around 24% of employed Australians worked from home one or more times/week[1]. During the height of the restrictions, WfH became the 'norm' for many office-based workers, as non-essential travel, travel to work and the workplace itself, were targeted as part of the virus containment strategies. This led to dramatic reductions in major modes of travel, a pattern repeat during the Delta-based lockdown in June-October, 2021 (Figure 1). As restrictions eased in mid/late-2020, it was evident that WfH in some capacity would likely remain both in the short term as a measure to reduce pressure on the transport network, CBD locations and high density office spaces, and risk of transmissible diseases[2], and the long term as employees and perhaps more importantly employers, saw it as a viable alternative[3]. Such was the shift, that by February, 2021, 41% of employed Australians now worked at home one or more times/week.

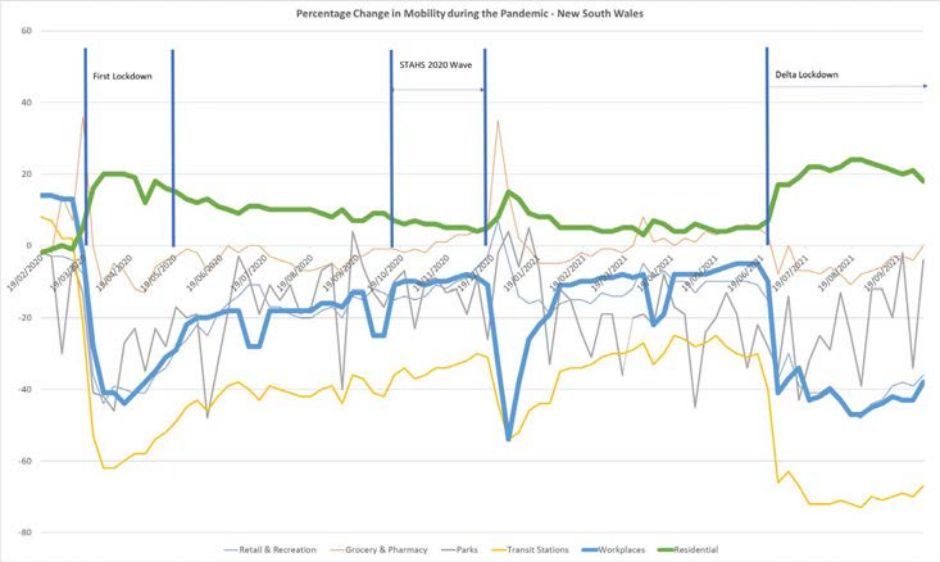

Figure 1: Mobility Impacts of the Pandemic in Sydney (Google Mobility Data available at *https://www.google.com/covid19/mobility/*)

[1] https://www.abs.gov.au/statistics/people/people-and-communities/household-impacts-covid-19-survey/feb-2021#work-from-home
[2] https://www.newscientist.com/article/2242113-australia-sees-huge-decrease-in-flu-cases-due-to-coronavirus-measures/. Accessed 06/06/20
[3] https://www.smh.com.au/business/companies/the-five-day-office-week-is-dead-long-live-the-hybrid-model-says-productivity-boss-20210706-p587d4.html

While allowing (some) WfH for employees is generally seen as a positive, questions continue to surface around how changes in working arrangements to be more home-based could impact health and wellbeing, particularly as travelling to/from/during work is an important source of active travel/physical activity and work itself comprises an important outlet for social interaction and inclusion. Given the large-scale return to WfH during the current lock-down and the likelihood that WfH will be an even greater feature of post-COVID scenarios, the current paper adds to a growing dialogue around the impacts of working at home on active travel, physical activity and wellbeing. Drawing from a survey of travel and health behaviour and social and wellbeing outcomes of 1,707 Sydneysiders conducted in late, 2020, when COVID-19 restrictions from the first outbreak had largely been eased, the paper addresses the following research questions: (1) *Have there been sustained significant changes in working practices (e.g., working at home, flexible working) following the first wave of the pandemic?* (2) *Have there been significant changes in active travel, physical activity and well-being that we can attribute to changes in working practices*?

2. Background/Literature

Teleworking/telecommuting, originated in the early 1970s, as a potential response to reducing congestion. Despite the appeal as both a travel demand management (TDM) strategy and attractive condition of employment, facilitated by technological advancements (particularly Home Internet capabilities), uptake of teleworking (now more generally termed Working from Home – WfH) has been much slower than predicted (Mokhtarian, 2009). The most significant issues appear to be related to ingrained ways of doing things and hesitation by managers to allow this to happen (Hopkins and McKay, 2019). Clearly, the pandemic changed the landscape by *forcing/mandating* the shift to WfH wherever possible, rather than it being *optional* to both employers and employees but this is now changing as restrictions ease.

Establishing the impacts of WfH is complicated due to a lack of consensus on what these impacts constitute and how to measure them, particularly given a dearth of longitudinal studies. In terms of transport changes, there are claims of shorter travel times and uptake of sustainable modes (Bieser, Vaddadi et al. 2021), as well as reduced traffic volume and air pollution (Giovanis 2018, Shabanpour, Golshani et al. 2018), but also reports of increased travel distance (Zhu 2012) and increased use of motor vehicles for non-work trips when working from home (Bieser, Vaddadi et al. 2021). Teleworkers report taking fewer commute trips but more non-work trips during the day (He and Hu 2015, Budnitz, Tranos et al. 2020), increasing overall travel distance. There is some evidence of an increase in walking and minutes of physical activity when teleworking at least 4 days a month (Chakrabarti 2018).

Health/wellbeing outcomes attributable to WfH are (arguably) even more challenging to identify and measure. Research points to an increase in job satisfaction and productivity when working from home (Gajendran and Harrison 2007, Felstead and Henseke 2017), but also an increase in feelings of stress and loneliness (Mann and Holdsworth 2003) as well as social and workplace isolation (Cooper and Kurland 2002, Daniel, Di Domenico et al. 2018). Conversely, there are reports of reduced stress and work-family-conflict for teleworkers (Montreuil and Lippel 2003). There seems to be an effect of teleworking intensity, with people who telework up to 2 days a week reporting positive job satisfaction and reduced stress (Delanoeije and Verbruggen 2020) or up to 8 hours a month reporting reduced depression (Henke, Benevent et al. 2016), but those who telework more than 2-3 days a week reporting negative health impacts (Gajendran and Harrison 2007). In a recent meta-review on this topic, drawing from 23 studies, Oakman (2020) identifies ten potential outcomes of WfH: pain, self-reported health, safety, well-being, stress, depression, fatigue, quality of life, strain and happiness. While there appears

little consensus around age, gender and other potential demographic correlates per se, the main issues seem to be various systemic moderators such as: the demands of the home environment, level of organisational support, and social connections external to work.

To date, while there has been a concerted push from the public health community to incorporate physical activity into the daily commute and other aspects of the work-day, there has been little focus on what happens as more working life is pushed to home. Are people becoming more sedentary and reducing physical activity or are they resorting to more conscious efforts to increase physical activity such as walking the dog or cycling to the local café?

3. Materials & Methods

An online survey capturing travel, work, health and wellbeing outcomes from 1,750 Sydneysiders was conducted in late, 2020, which after data error checking, resulted in a usable sample of 1,707 participants – restrictions had largely been eased by this time in Sydney. Given the focus of this analysis was on changing work practices, participants who primarily identified as workers (full-time, part-time, casual) were selected resulting in a usable sample of 1,165 workers[4]. Table 1 shows the composition of the sample. The gender split was equal with a reasonable distribution across age categories. Around two-thirds of participants had a Tertiary education, with a median income of $130,000, with office-based occupations dominating.

Table 1: Sample Characteristics of Participants Identified as Workers

n = 1,165	No.	%		No.	%
Gender			**Annual Household Income**		
Male	581	49.9	Less than $80,000	264	22.7
Female	584	50.1	$80,000 - $140,000	420	36.1
Age Category			$140,000 or more	350	30.0
18-24	79	6.8	Missing	134	11.2
25-34	252	21.6	**Occupation**		
35-44	366	31.4	Manager	283	24.3
45-55	265	22.7	Professional	368	31.6
56-64	164	14.1	Technicians and trades	72	6.2
65-69	39	3.3	Community and personal services	72	6.2
Highest Level of Education			Clerical and administration	237	20.3
HSC/SC	156	13.4	Sales	65	5.6
Trade or Tafe	213	18.3	Machine operators/drivers	25	2.1
Tertiary	788	67.6	Labourers	43	3.7
Missing	8	0.7			

4. Results

4.1. Changes in Work and Working from Home

Participants were asked about days worked and days worked at home in a typical week pre-COVID and in the last working week preceding the survey. Figure 2 indicates the relative change between waves. Overall, the proportion of participants WfH at least one day/week increased from 33% to 58%, while the proportion of WfH/Days Worked increased from 19%

to 48%. This suggests both an increase in the numbers WfH in some capacity and an increase in the proportion of work done at home – particularly notable is the evident shift to full-time WfH (taken as 5 days or more) for around 20% of the sample.

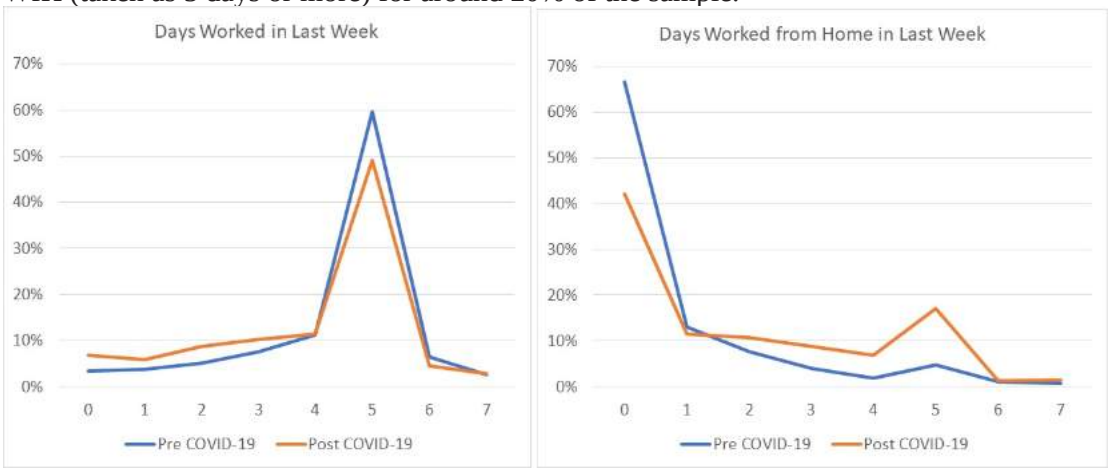

Figure 2: Changes in Work Pre-Post First Wave of COVID-19

4.2 Impacts on Physical Activity, Active Travel & Well-being

Participants were asked to indicate their level of change in physical activity, active travel, and general wellbeing compared to before COVID-19 restrictions. These were cross-tabulated with self-reported changes in working from home (Table 2) – note, these are participants who reported some WfH in the before and/or after periods *not* the entire sample of workers. Evidently, increased WfH is associated with an increase in sitting – this is illustrated most dramatically with 70% of those who reported a lot more WfH indicating they were sitting more. Increased WfH is also associated with a greater likelihood of reporting being anxious/depressed and greater concern around the future although this is not as starkly evident for those reporting a lot more WfH as with sitting.

Table 2: Changes in Physical Activity, Active Travel & Wellbeing

		Change in Working from Home					
Compared to before the COVID-19 restrictions, I am….	*Overall*	A lot less	A little less	No change	A little more	A lot more	Spearman's Rho
More physically active	*37%*	20%	26%	26%	47%	43%	0.081*
Less physically active	31%	68%	37%	21%	23%	36%	
Sitting more	*56%*	38%	36%	35%	58%	71%	0.332**
More anxious or depressed	*44%*	19%	33%	41%	56%	55%	0.214**
More concerned about the future	*67%*	51%	44%	51%	76%	72%	0.206**
Walking to work more	*23%*	24%	22%	16%	30%	25%	-0.170**
Walking to work less	32%	51%	39%	12%	13%	52%	
Cycling to work more	*25%*	26%	19%	10%	33%	34%	0.083*
Cycling to work less	23%	45%	38%	10%	15%	31%	
Walking more for non-work purposes	*40%*	33%	15%	23%	46%	51%	0.160**
Cycling more for non-work purposes	*31%*	23%	20%	16%	36%	46%	0.258**
Walking the dog more	*41%*	24%	24%	22%	53%	56%	0.343**
Walking/cycling for leisure more	*42%*	28%	31%	24%	53%	52%	0.184**
Walking/cycling for exercise more	*40%*	29%	42%	24%	47%	47%	0.149**

**Significant at 95% confidence level; **Significant at 99% confidence level*

In terms of physical activity, the marginally significant association with increased WfH, reflects the fact that while over 40% of participants reported an increase in physical activity, over one-third reported they were doing *less* physical activity. Evidently, some of these gains in physical activity are being captured through conscious efforts to walk and cycle more for non-work purposes, leisure and exercise, while less use is made of walking to access work.

5. Discussion

Experiences with WfH are highly variable based on the metrics considered here. Perhaps of most concern (arguably) is the large increase in sitting, corroborated by evidence elsewhere also in connection with an originally 'forced' large-scale move to WfH due to the pandemic (Koohsari et al., 2021). The consequences of sitting for extended periods of time are well-documented, particularly when combined with greater sitting for leisure/recreation (Oakman, 2020). As the need to travel to work and move during the day to attend meetings etc has been replaced by a laptop on the kitchen table and Zoom, people are invariably sitting more. While the onus has largely been on the individual to take responsibility for ensuring they take breaks, aided by a multitude of apps reminding them to do so (e.g., Tomato timer, Awareness), clearly there is a responsibility here on the employer as well to ensure they both provide opportunities for and encourage their employees to take regular breaks away from the screen. Similarly, the findings around greater anxiety/depression and concern, while clearly compounded by the pandemic, point to the need for greater efforts to ensure that any feelings of isolation and loss of social connections through work are addressed through regular interactions of both a work and social nature (Oakman, 2020). The loss of the daily commute and intra-day travel at work are clearly lost opportunities for building in active travel and associated physical activity benefits. The results here suggest that a significant proportion of people are compensating by making more conscious efforts to use 'active modes' for local travel, recreation and exercise. Equally, a significant proportion of participants have reported doing less physical activity with presumably less opportunity or inclination to do so. Given the substantial growth in WfH and likelihood this will continue post-COVID, it is clearly critical that awareness of these issues is on the radar of both employers and government agencies in their planning, policies and messaging for the future.

6. Next Steps

This extended abstract presents the first stages of an ongoing analysis with a view to seeking feedback and generating discussion at the conference. We are currently completing a more nuanced analysis examining the potential covariates (e.g., occupation, gender, age, household size etc) underlying the results here and will present these at the conference.

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SESSION 7D: ECONOMICS

Moving international shipping containers at seaports: A case study for Melbourne [35]

Michael Tucker *(C F Technologies Pty Ltd),* ***Dimitris Tsolakis*** *(C F Technologies Pty Ltd),* ***Philip Norman*** *(C F Technologies Pty Ltd) and* ***Russell Thompson*** *(University of Melbourne)*

Abstract

Moving international shipping containers "the last mile" into seaports in prime real urban estate has been a challenge. A review of key trends finds that the exponential growth of seaport infrastructure is unsustainable. The ability to achieve accurate scheduling of rail and road resources is frustrated by multipurpose infrastructure needed to accommodate both people and freight frequency of movements which also requires land for storage capacity close to the port. A response to these challenges is addressed by the innovative approach of Container Freight Technologies (CFT) with ambitious plans to shake up the international logistics industry. The core innovation of CFT proposes a revolutionary new system for transporting shipping containers. A first attempt is made to evaluate CFT designs and processes. Different scenarios of truck replacement are examined for optimal outcome. The proposed CFT innovation suggests economic feasibility when it replaces 20% or more container freight trucks, warranting further work.

Crowding costs and expansion factors for Sydney's heavy rail network [76]

Alexander Svanberg *(Transport for NSW)*

Abstract

Sitting and standing on trains in crowded conditions creates discomfort and anxiety for rail customers, a cost which is measured and monetized in cost-benefit analysis (CBA). This document expands on the crowding cost methodology and parameters estimated in Douglas (2006) and the Transport for NSW (TfNSW) Economic Parameter Values to calculate the average daily and total crowding costs across Sydney's heavy rail network (pre COVID-19) using Opal ticketing data. Given transport demand modelling is often only undertaken for the AM or PM peak hour period, this document also provides cost expansion factors for Sydney, which allows CBA practitioners to estimate full-day and annual crowding costs from peak hour modelling. This paper finds that crowding costs on the Sydney heavy rail network exceeded a hundred million dollars in 2019, and that expansion factors varied significantly across different heavy rail lines.

'When the bough breaks': critical question for the crafting of Australia's bus franchises in the era of electric fleet [102]

David Ashmore *(TSA Advisory),* ***Michael Gregorevic*** *(Systra),* ***Andrew Lau*** *(TSA Advisory),* ***Catie Moore*** *(Mills Oakley) and* ***Parry Serafim*** *(Bus Association Victoria)*

Abstract

Within Australasia bus services are generally let under contract to private sector operators for a finite contract period. Where contestability is seen as possible these contracts are put to the market via public tender; when an incumbent is thought to be unseatable the preferred model of procurement is typically open book negotiation. Contracts are usually gross cost with minimal patronage risk, performance incentives for reliability and punctuality, and in some cases, assets lie with the state so as to maximise market competition. In recent years the drive towards decarbonisation has spawned a plethora of state and federal policy documents committing to the replacement of diesel buses with electric vehicles. In some states ambitious replacement targets have been stated-e.g., no more diesel buses to be purchased after 2025 - and in a handful of instances electric fleet has been mandated in tenders. There are, however, considerable transition risk issues in moving from diesel to electric fleet, ranging from capital cost uplifts, uncertainty in the operating cost profile, and the ability of the electricity grid to sustain mass fleet charging in the off peak. The franchise contracts though are not designed to cope with significant variations in capital and operating cost over their life – traditionally they accommodate only moderate fleet replacement and service variations, not significant spikes in risk, which cannot be priced

into a competitive tender. This raises the risk of predatory bidding or a significant uplift in tender prices. This paper probes these issues and asks to what degree the contracting model needs to be modified to accommodate seismic shifts such as a transition to electric fleet.

Global market appetite for metro rail [17]

Brendon Baker *(Mott MacDonald),* ***Anne Schaefer*** *(Mott MacDonald),* ***Arj Sreedhar*** *(Mott MacDonald) and* ***Matthew Van Der Westhuizen*** *(Mott MacDonald)*

Abstract

Large infrastructure programs such as railway developments across the globe have the potential to attract a large number of local and international industry actors wanting to participate in the delivery of individual mega-projects and a pipeline of infrastructure initiatives. The level of international participation can vary significantly depending on the geographical location of the project and the procurement approach taken by clients. Our summary report aims to understand procurement strategies and engagement initiatives by different client organisations in different jurisdictions. Drawing on global experience, insights can be identified that may assist in removing potential blockers to those industry actors that are not participating in the Australian market. A total of three case studies were developed for this research project: Doha Metro (United Arab Emirates), Los Angeles Metro (USA), and Ontario Line (Canada). Insights from these case studies are considered in relation to the Sydney Metro mass transit program (Australia).

SESSION 8A: SOCIAL/ECONOMICS

Birds and roads: A longitudinal study of a major road project in SEQ [48]

Christopher Johnson *(Cities Research Institute),* ***Darryl Jones*** *(Centre for Planetary Health & Food Security) and* ***Matthew Burke*** *(Cities Research Institute)*

Abstract

Roads allow for the transport of people and the safe distribution of services and products but can cause significant negative impacts for wildlife. Impacts include disruption of migration pathways, increased mortality through exposure to vehicle collisions, and reduced physiological condition, particularly where these intersect natural reserves. The aim of this presentation is to explore the innovative research methods developed for a novel study monitoring the influence of road construction on the presence and dispersal of the wildlife community, specifically birds. The presentation covers the background issues around birds and roadside ecology, the Queensland site where the research is being conducted, and a summary of the key methodologies that will be used.

Measuring the distributive impacts of electric vehicle policies [133]

Vincent Benezech *(Veitch Lister Consulting),* ***Nancye Ng*** *(Veitch Lister Consulting) and* ***Adam Basile*** *(Veitch Lister Consulting)*

Abstract

The number of battery electric vehicles (BEVs) sold in Australia is low compared to other Organisation for Economic Co-operation and Development (OECD) countries, primarily because of a historic lack of supportive policies. However, several Australian States have recently announced or are developing electric vehicle (EV) policy packages to boost BEV uptake. Veitch Lister Consulting (VLC) has developed a model to assess the impacts of EV policies. This paper introduces a spatial EV uptake model and illustrates how it can be used to assess the aggregate and distributive impact of policies. We first outline the methodology behind the model and present its key inputs and parameters. We then

analyse the impact of two potential EV-related policies: the introduction of road-user charging and an exemption of EVs from transfer duty.

SESSION 8B: URBAN DESIGN

Estimating location choice models in Australia [114]

Stuart Donovan *(Vrije Universiteit Amsterdam),* ***Henri L.F. de Groot*** *(Vrije Universiteit Amsterdam) and* ***Thomas de Graaf*** *(Vrije Universiteit Amsterdam)*

Abstract

We present preliminary results from ongoing research that seeks to estimate the location choice model formulated in Ahlfeldt et al. (2015), in which the cost of commuting affects where workers choose to live and work. Using data for six Australian cities with populations ranging from 200,000 to over 5 million, we find the effects of commuting costs on location choice vary significantly between cities and across specifications. Our preferred model yields effects that are approximately 20% larger than conventional specifications.

Lessons for adopting microeconomic land use models at the city scale: Perth case study [116]

Doina Olaru *(University Western Australia) and* ***Brett Smith*** *(University Western Australia)*

Abstract

Major transport infrastructure has the potential to significantly influence land use development, with increased development likely along its corridors. The land use (population and employment) inputs into the Perth Strategic Transport Models are currently produced at the small area level using a rule-based approach, Metropolitan Land Use Forecasting System (MLUFS). This approach does not explicitly take accessibility into account and limits the analysis of transport infrastructure programs and their impact on land-use intensification. An improved behaviour-based strategic land-use model to predict the potential impacts of major transport infrastructure on land-use development patterns was identified as a modelling imperative for Western Australia's planning and transport agencies (Taplin et al., 2014). CUBE Land was selected because it is behaviourally sound and specifically addresses the land-use and transport interaction. This paper presents an active research case study, undertaken by researchers at PATREC, on the implementation of an equilibrium land use model for Perth.

Understanding the allocation and use of street space in activity centres [18]

Chris De Gruyter *(RMIT University),* ***Seyed Mojib Zahraee*** *(RMIT University) and* ***William Young*** *(Monash University)*

Abstract

The allocation of street space is strongly contested in many cities, particularly in activity centres where movement and place objectives are often in conflict with one another. Using a case study of Melbourne's activity centres, the aim of this research was to understand how much street space is allocated and used by each mode of transport, and to explore factors that are associated with the use of each mode of transport. Multi-modal observational person counts and street measurements were undertaken at 57 different locations within 36 activity centres across Melbourne during 2020. For each site, data related to street and activity centre characteristics were compiled. Key results showed that, on average, pedestrian space in the form of footpaths is significantly undersupplied, while bicycle lanes, car parking and shared general traffic/bus lanes were oversupplied. However, when viewed across individual sites, considerable variability was found in street space allocation vs. use. Results also showed a number of street/activity centre characteristics that were associated with use of the street space by mode. Among others, these included footpath width, clearways, movement and place classifications, distance to the CBD, presence of car sharing, car ownership, income and age. The research findings can be used to better inform decision-making on street space reallocation through identifying locations where street space could be allocated more equitably to users.

SESSION 8C: TRAFFIC MODELLING

An overview of dynamic traffic assignment models in practice [94]

Neeraj Saxena *(Australian Road Research Board (ARRB)),* ***Elnaz Irannezhad*** *(Australian Road Research Board (ARRB)) and* ***Wesley Soet*** *(Main Roads Western Australia (MRWA))*

Abstract

Dynamic Traffic Assignment (DTA) has received increasing attention in recent years, and there are numerous examples of practical implementations. While the existing strategic planning models in practice are used for long-term travel demand forecasting, they do not quite realistically represent traffic dynamics which are necessary to assess traffic management measures and policies. Thus, DTA modelling has significantly grown into a vast area in transportation engineering in the past two decades. There do exist different types of DTA applications which can largely be classified into analytical and simulation-based DTA. As these are relatively new concepts, practitioners are often posed the challenge of selecting the right DTA tool which is appropriate for the problem context, time and budget constraints. This paper aims to describe, from practitioner perspective, the key concepts in DTA, previous applications of DTA models nationally and internationally, and a few DTA oriented software tools in practice. The core components of DTA frameworks are discussed including the three Dynamic Network Loading (DNL) modules namely: macro-, meso- and microscopic. The choice of a DNL determines whether the DTA framework is analytical or simulation-based. This paper summarises a few real-world applications of the DTA models across Australia and New Zealand and abroad. Lastly, this paper also lists out a few available software packages in practice and where do they align in the traffic assignment-DNL diagram. Another classification software tools based on analytical and simulation-based DTA is also presented. This paper will extend the knowledge of practitioners in DTA modelling and also provide awareness regarding when DTA models are appropriate and which type and software tool to undertake a DTA project should be selected.

Car following modelling with constrained generative adversarial imitation learning [69]

Lin Lin *(The University of Queensland),* ***Jiwon Kim*** *(The University of Queensland) and* ***Sanghyung Ahn*** *(The University of Queensland)*

Extended Abstract

1. Introduction

Traffic simulation plays an important role in traffic planning and management. Since microscopic modeling can capture individual vehicle movements and interactions at the highest level of detail, it is implemented in major traffic simulation software and car following is a significant component in those simulators. Most of the existing car following models are theory- or model-based in that a driver's action (e.g., acceleration) is described as an analytical function of a set of parameters representing traffic states and driver characteristics, which are based on physics or behavioural theories. While various car-following models have been widely adopted in microscopic simulation research, such as Gipps model and Intelligent Driver Model (IDM), there are limitations of these theory-based models, one of which being the limited number of parameters that are often insufficient to capture and generalise complex human behaviours. On the other hand, data-driven, machine learning models like neural networks can embed and generalise much richer information through a more flexible model structure and larger parameter set. As such, there is an increasing interest in developing data-driven traffic simulation models in the transport research community and this study aims to investigate the possibility of developing a car-following model using emerging deep learning techniques.

Among deep learning models, Recurrent Neural Network (RNN) has been widely used in solving sequential problems due to its ability to learn long-term dependencies on sequential data. In 2014, Generative Adversarial Network (GAN) [1] was introduced, which has become the most popular algorithm used in synthetic data generation including image, audio and text generation. Several studies that combine Long Short-Term Memory (LSTM) network, which is a kind of RNN, and GAN obtain novel results on synthetic trajectory generation [2]. Meanwhile, Reinforcement Learning (RL), which is formulated based on Markov Decision Process (MDP) and aims to solve sequential decision-making problems, saw significant improvement after integrating with deep neural networks and produced well-known applications like AlphaGo and self-driving cars. In RL, the key is to define a reward function that gives an RL agent proper signals to guide its actions. However, it is often difficult to manually design the reward function in complex problems and, thus, Inverse Reinforcement Learning (IRL) [3] and Imitation Learning (IL) were proposed, which can learn the reward function from experts' demonstrations observed from data. In 2016, Generative Adversarial Imitation Learning (GAIL) [4] was proposed, which is a combination of IL and GAN. In GAIL, training is conducted through a zero-sum competition between a policy network and a discrimination network, where the discriminator serves as a reward signal for the RL problem. Recently, studies have applied GAIL in the context of car-following modelling [5][6]. However, due to the nature of IL that learns a reward function solely from data, there is little control over the undesirable behaviours of the RL agent representing a driver. For instance, the driver may end up following too close to the leading car, resulting in a collision, or even moving backward as there are no explicit signals to avoid such states within the IL framework. To address this challenge, we propose a *Constrained-GAIL* framework that utilises the *reward augmentation* technique that was introduced in a multi-agent traffic study [7]. This reward augmentation

allows additional constraints to be imposed through a manually designed reward function, on top of the reward function learned from the original GAIL. In this way, driving agents can be guided to avoid unwanted states, thereby reducing unrealistic or dangerous events. We demonstrate our proposed model using the NGSIM dataset, and the result shows higher prediction accuracy in terms of vehicle speed and location, while minimizing unwanted behaviours including collision and backward driving.

2. Method

2.1. Formulation

The car-following behaviour of a driver is formulated as an MDP in the RL setting, where the RL agent represents the following car and aims to learn the optimal policy (π) through trial and error. A policy is a stochastic rule by which the agent selects actions as a function of states and the agent keeps correcting its policy by comparing its trajectories with the ground-truth trajectories (expert demonstrations) from the dataset.

The MDP is defined as a tuple (S, A, T, R, γ), where S is the state space including the speed of the following car, speed difference and distance to the leading car, A is the continuous action space representing the range of acceleration values the following car can choose, T stands for the transition probabilities describing the probability of moving one state to another given an action, R denotes the reward function obtained from the demonstrated trajectories in the dataset, and γ denotes the discount factor reflecting how much the agent cares about the reward in the distant future compared to the immediate reward. At every time-step, the RL agent (following car) observes a state and chooses an acceleration value based on its policy (π). It then gets to the next state according to the transition probabilities, meanwhile receiving a reward. In most cases, the transition probabilities are unknown, but the environment is fully observable to get the next state information. The aim to solve the MDP is to get the optimal policy that can give the largest accumulated reward in a complete journey from the origin to the destination.

In GAIL, a discriminator is introduced to the above-mentioned RL context and tries to distinguish state-action pairs of the trajectories generated by the agent's policy (π) from those generated by the expert's policy (π_e). Learning becomes a *minimax game* between the discriminator and the policy, where the discriminator tries to maximize its classification ability and policy tries to generate realistic trajectories to fool the discriminator, as shown in following formulation:

$$\min_{\pi} \max_{D\in(0,1)^{S\times A}} \boldsymbol{E}_{\pi}[\log D(s,a)] + \boldsymbol{E}_{\pi_e}[\log(1-D(s,a))] - \lambda H(\pi)$$

where π is the policy imitating expert policy π_e, D is the discriminator, and H(π) is the causal entropy of the policy π. The goal is to find policy π that minimises the distance between the distribution of generated state-action pairs and the distribution of expert state-action pairs. Since the discriminator gives higher scores to ground-truth state-action pairs and lower scores to generated ones, it can be served as a reward signal in the RL problem. The reward function is thus obtained from expert demonstrations directly through discriminator.

The constrained-GAIL minimax problem is solved by transforming to an unconstrained form of GAIL to a constrained form by adding a regularizer to the formulation as follows:

$$\min_{\pi_\theta} \max_{D\in(0,1)^{S\times A}} \boldsymbol{E}_{\pi_\theta}[\log D_\omega(s,a)] + \boldsymbol{E}_{\pi_e}[\log(1-D_\omega(s,a))] - \lambda H(\pi) - rE_{\pi}[I_u]$$

where r is the penalty and I_u is an indicator function which will be zero if the state-action pair does not lead to an undesired state [7]. The policy and discriminator are represented by deep neural networks parameterized by θ and ω. The constrained GAIL model is trained to find the optimal parameters by alternating between a gradient step to increase the formula above with respect to the discriminator parameters ω and a Proximal Policy Optimization (PPO) step to

decrease above formula with respect to θ. The optimal policy and discriminator will be obtained after training is complete.

2.2. Model Structure

The model architecture of the proposed constrained GAIL to predict a driver's car-following behaviour is shown in Figure 1. At each time step, the generator outputs the following car's acceleration based on the input state considering the current speed and the relation with the leading car. These generated state-action pairs along the whole trajectory are then compared with the state-action pairs from the real dataset through the discriminator. Both the generator network and the discriminator network got optimized through the training iterations.

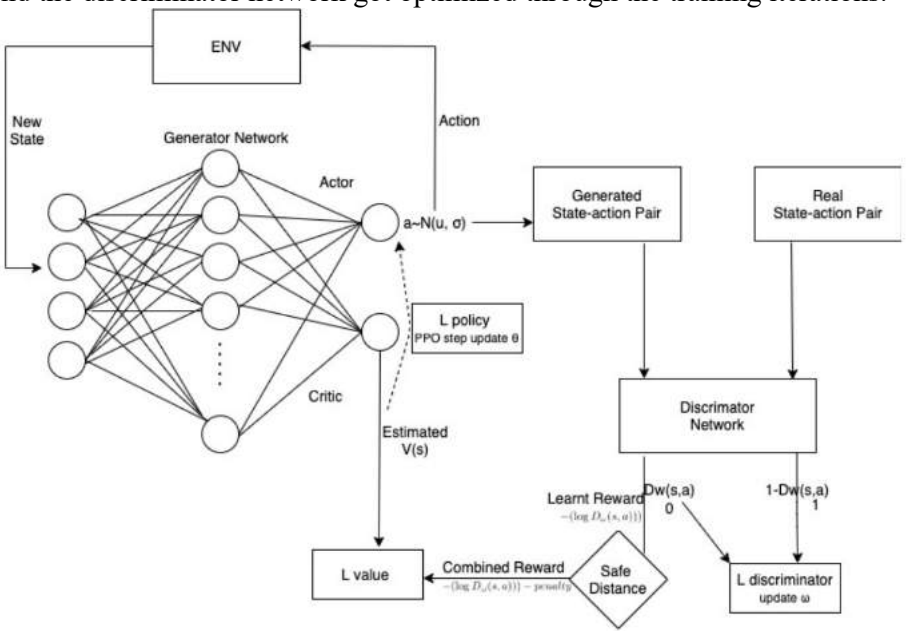

Figure 1: Network structure

The generator network utilizes an *Actor-Critic* framework, and the PPO algorithm is used to update the gradient of the policy. With each update, the new policy should have a higher probability of generating actions with larger rewards than the previous policy. In the Actor component, a distribution of actions is outputted and the acceleration of the following car is actually drawn from this distribution, while from the Critic component a value evaluating the goodness of the action is outputted. The discriminator network is in charge of judging how close the real state-action pairs from the dataset and the generated state-action pairs from the policy network are. The cross-entropy of these two sets of state-action pairs is calculated and the training is conducted to find the parameters that lead to the maximum cross-entropy. With the extra augmented reward, rules or constraints can be integrated into the network. In this study, two types of constraints are considered: one specifying the minimum distance between the leader and follower to prevent a collision and the other not allowing a negative speed to prevent driving backward. A constant penalty is added if the distance between the following car and the leading car is less than 2 meters or when the speed is negative.

2.3. Dataset

This work uses the NGSIM I-80 dataset [8], which contains 45 minutes of detailed trajectory data from eastbound I-80 in the San Francisco Bay area in Emeryville, CA, on April 13, 2005. A total of 889 pairs of car-following trajectories are extracted from the dataset, where vehicles

with lane change behaviours have been excluded. Among them, 647 pairs (4:00 - 4:15 p.m.; 5:00 - 5:15 p.m.) are used as training data and 242 pairs (5:15 p.m. - 5:30 p.m.) as testing data.

3. Result

The accuracy of the constrained GAIL model is measured by the Root Mean Square Error (RMSE) of speed and location and the Modified Hausdorff Distance (MHD) [9] of location between the modelled trajectories and the ground-truth trajectories. The ability to prevent unwanted behaviours is measured by the frequencies of collisions (collision ratio) and backward driving observations (negative speed ratio). The model performance was measured for the distance-constrained version (GAIL-distance) and the speed-constrained version (GAIL-speed), separately. These two models are also compared with other benchmark models including the original GAIL model, IDM, and Behavior Cloning (BC) model. Table 1 shows the performance comparison results. The distance-constrained GAIL achieved the lowest error among all the models, where collision and backward driving frequencies are much lower in GAIL-distance than in the original GAIL and BC model. IDM achieves the similar speed RMSE with GAIL, but shows higher location RMSE.

Model	Speed RMSE	Space RMSE	MHD	Crash %	Negative Speed %
GAIL	1.173	9.269	5.709	7.40%	3.48%
GAIL-distance	1.052	7.248	3.971	0.20%	0.20%
GAIL-speed	1.155	11.028	7.693	0.00%	0.00%
BC	1.951	15.545	9.144	7.00%	0.58%
IDM	1.216	10.482	5.578	0.00%	0.00%

Table 1: The results of Speed RMSE, Location RMSE, MHD, Collision Ratio and Negative Speed Ratio

The spacing (the front-to-front distance) between leading and following cars generated by different models are shown in Figure 2 to investigate the effectiveness of adding extra constraints through reward augmentation to the GAIL framework. For a given leading car trajectory, the spacing results produced by the original GAIL, the proposed distance-constrained GAIL (GAIL-distance), and IDM model are compared to the ground-truth results (NGSIM). Abnormal overtakings occur in the original GAIL, which are reflected by the negative spacing values, while such abnormal behaviours are not observed in the distance-constrained GAIL, indicating the reward augmentation successfully imposes the desired constraints.

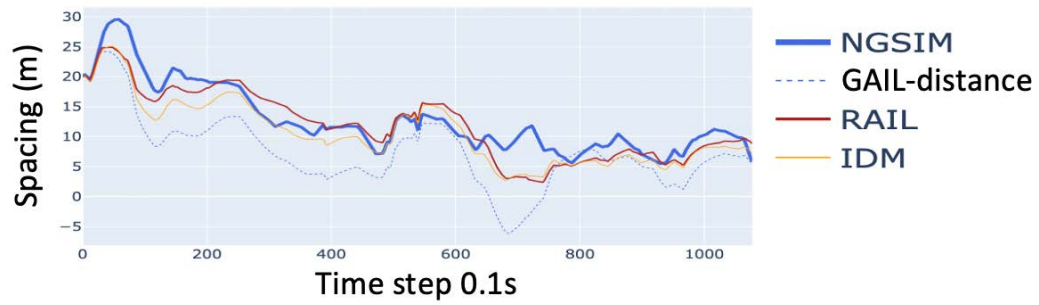

Figure 2: Spacing between following car (#1543) and leading car (#1539) from the NGSIM data and the models

The similarity between the model-generated trajectories and the NGSIM trajectories is also evaluated by comparing the speed distributions, as presented in Figure 3(a). The distance-constrained GAIL eliminates negative speeds and produces the speed distribution similar to the

actual NGSIM data, whereas the original GAIL produces negative speeds. Compared to IDM, the distance-constrained GAIL matches the speed distribution of the NGSIM better, especially in the right tail where similar high speed ranges are observed between the GAIL-distance and NGSIM, as shown in Figure 3(b).

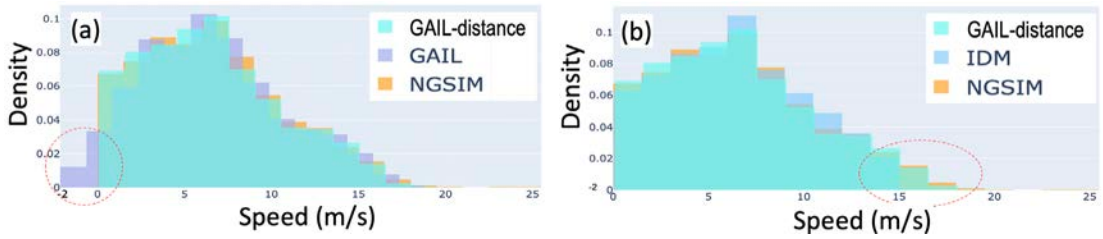

Figure 3: The comparison of speed distributions among (a) GAIL-distance, GAIL, and NGSIM data (b) GAIL-distance, IDM, and NGSIM data

4. Conclusion

This study demonstrates a data-driven car-following model based on GAIL, where augmented reward signals can be integrated into the imitation learning framework to impose extra constraints or penalties to more effectively guide a learning agent's behaviour. The experiments conducted using the NGSIM trajectory data show that the proposed constrained-GAIL framework can improve the model prediction accuracy, compared to the conventional theory-based car-following model (IDM) and the existing imitation learning models (GAIL and BC), while successfully preventing unwanted behaviours like collision or backward driving, which is crucial to perform a realistic simulation of safety-critical scenarios. Several extensions and improvements to the current model are possible. Since the proposed framework is general and flexible, it could be applied to other microscopic traffic simulation problems like lane changing or multi-agent scenarios. Another improvement could be extending the models with latent variables like infoGAIL, which can capture and classify different behaviours and patterns in an unsupervised manner.

Acknowledgements

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Modelling travel time variability within transport networks: A practitioner oriented approach [95]

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Abstract

The Australian Transport Assessment and Planning (ATAP) guidelines have been developed to assist planning, assessing, and developing transport systems and initiatives. It is widely recognised that travellers take into consideration travel time reliability in their travel decision making. Therefore, the benefits of improved travel time reliability ought to feature in appraisal of transport related initiatives. While modelling travel time variability has been widely studied by researchers, the methods lack a practitioner-friendly approach. The aim of this work was to propose calibrated, practitioner-ready formulae to determine travel time variability at a resolution of a link and a route. Specifically, the team used data (observed travel times and their standard deviations) from different jurisdictions across Australia to develop formulas that can be applied to a range of road stereotypes (capacity and congestion). For the link travel time variability, an exponential functional form was developed, referred to as the ATAP model, and was found to outperform other shortlisted models. Separate ATAP model parameters were calibrated for arterial and freeway links. The calibrated models were also validated using travel time data from Australian states. For the route travel time variability, a Correlation Route Model (CRM) is recommended which comprises two components: ATAP model and the Correlation Coefficient Model (CCM). This paper utilises the Western Australia Wanneroo Road Duplication project as a case study to demonstrate the application of CRM on a defined route to estimate the change in travel time reliability and compare against the measured change from field data. The case study results substantiated the accuracy of CRM in predicting observed route travel time SD. This work provides simple equations which can be quickly applied by practitioners to determine expected travel time variability in a road network and utilise it in transport planning and economic appraisal applications.

SESSION 8D: SAFETY

Emergency search plan for complex premises [44]

Saeed Asadi Bagloee *(The University of Melbourne) and* ***Majid Sarvi*** *(The University of Melbourne)*

Abstract

Terrorist attacks, natural disasters are on the rise. Land scarcity has forced cities to grow vertically. As a result buildings are becoming a complex environment, posing remarkable challenge for first-responders in emergency situations. Of the most important operations in emergency management is to conduct a timely search of premises. The question of interest is how many firefighters are needed and what are their search plans? Though it is a crucial question, the literature and industry have yet to address it. To this end, we propose a two-phase methodology to draw up the most efficient and timely search plan, called “search map”. In the first phase a minimum number of firefighters is identified. In the second phase, search maps (or routes) for each firefighter are identified. We demonstrate that these two phases have strong resemblances to two famous and quite difficult mathematical problems, namely the “Chinese Postman Problem” and the “Vehicle Routing Problem”. We encode the methodology as two optimization problems which are then solved by two leading optimization software package: GAMS and MATLAB. Numerical results of a large sized floor plan is presented and discussed. The two-phase setup results in an efficient methodology which makes it a suitable tool for addressing real-time emergency responses in rapidly changing indoor environments. The results can be integrated in Building Information Management (BIM) systems and city/building 3D models.

Efficient estimation of crash count data via meat-heuristic solution algorithm [90]

Zeke Ahern *(Queensland University of Technology),* ***Alexander Paz*** *(Queensland University of Technology) and* ***Paul Corry*** *(Queensland University of Technology)*

Abstract

Many sophisticated modelling approaches have been developed to estimate advanced specifications capable of dealing with crash data issues such as unobserved heterogeneity and excessive zero observations. However, a superior approach for all cases is not currently available because models are mostly data-dependent. Additionally, the development of crash estimation models is complex, time-consuming, subject to experience, advanced knowledge, and ad hoc processes. This conference paper provides a mathematical programming formulation and solution algorithm to assist the analyst in the development of advanced crash-frequency estimation models while saving time and minimizing human bias and error. This is achieved by wrapping an ad hoc processes into the solution algorithm and searching for best-fit combinations to obtain an adequate function specific to the data.

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AUTHOR INDEX

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PROGRAM OVERVIEW

WEDNESDAY 8 DECEMBER	
8.00am – 5.00pm	Registration Desk Open
8.00am – 9.00am	Coffee & Networking
9.00am – 10.30am	Opening Plenary
10.15am – 10.30am	Housekeeping
10.30am – 11.00am	Morning Tea
11.00am – 12.20pm	Concurrent Session 1
12.20pm – 1.10pm	Lunch
1.10pm – 1.55pm	Debate: That micromobility is good for cities
2.00pm – 3.20pm	Concurrent Session 2
3.20pm – 3.40pm	Afternoon Tea
3.40pm – 4.40pm	Concurrent Session 3
4.40pm	Close Day One
6.00pm – 7.30pm	**Welcome Reception** (Sponsored by Griffith University)

THURSDAY 9 DECEMBER	
8.00am – 5.00pm	Registration Desk Open
8.00am – 9.00am	Coffee & Networking
9.00am – 10.25am	Plenary 2
10.25am – 11.00am	Morning Tea
11.00am – 12.20pm	Concurrent Session 4
12.20pm – 1.20pm	Lunch (Sponsored by NineSquared)
1.20pm – 2.05pm	Debate: That Sports Events Create a Great Transport Legacy
2.10pm – 3.30pm	Concurrent Session 5
3.30pm – 3.50pm	Afternoon Tea

FRIDAY 10 DECEMBER	
8.00am – 1.30pm	Registration Desk Open
8.00am – 9.00am	Coffee & Networking
9.00am – 10.20am	Concurrent Session 7
10.20am – 10.40am	Morning Tea
10.40am – 11.40am	Concurrent Session 8
11.40am – 11.45am	Move to closing plenary room D-101
11.45am – 12.30pm	Closing Plenary: Paper Prizes and Report from the ATRF President
12.30pm – 1.30pm	Lunch
3.30pm – 5.00pm	Tours