

Limitations of AI in HDR study

Yongze Song
School of Design and the Built Environment
Curtin University

15 September 2025

Introduction

- PhD students' research and study emphasizes originality, depth, and critical thinking
- AI is increasingly used in research (writing, literature search, data analysis)
- Question: what are limitations of AI in research and study?



(Source: Google image)

AI advantages

Examples in built environment research

- Helps improve language quality
- Assists in improving research efficiency
- Quickly integrates information from literature
 - AI can help design, manage, and optimise green infrastructure (GI) for cooling and water management (Shaamala 2024)
- Recognizes patterns and processes data
 - Foundation models can be used in both text-only geospatial tasks (e.g., location recognition, health forecasting) and multimodal tasks (e.g., urban function, noise, remote sensing) (Mai 2023)

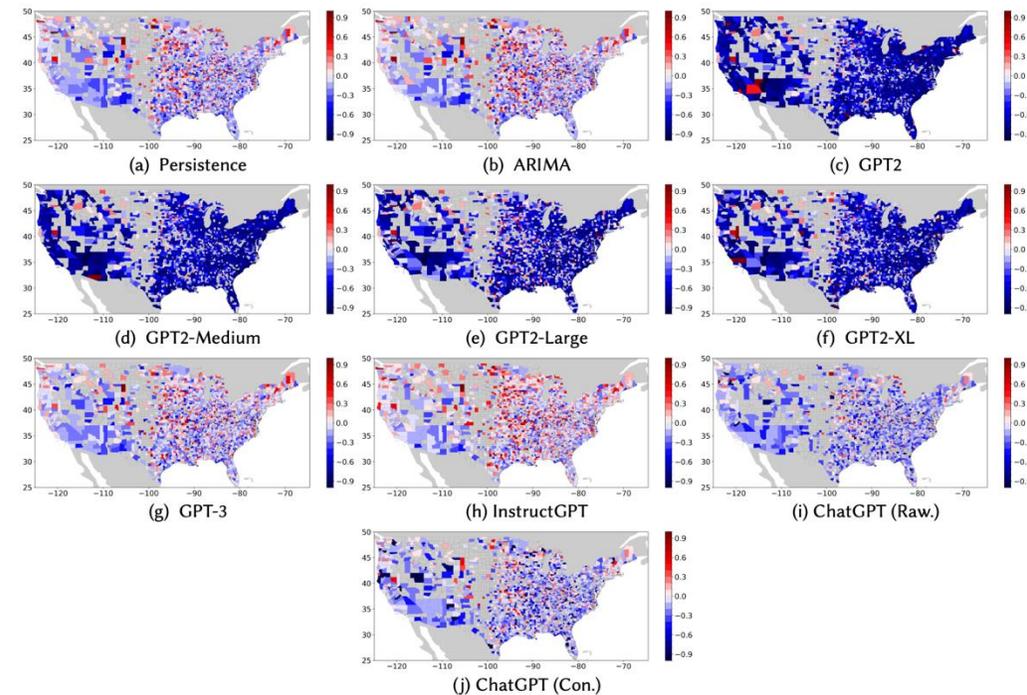


Fig. 1. Prediction error maps of each baseline and GPT model on US county-level dementia death count time series forecasting task. The color on each US count indicates the percentage error $PE = (Prediction - Label)/Label$ of each model prediction on this county. Those counties in gray color indicate their dementia data during 1999 and 2020 are not available.

(Mai 2023)

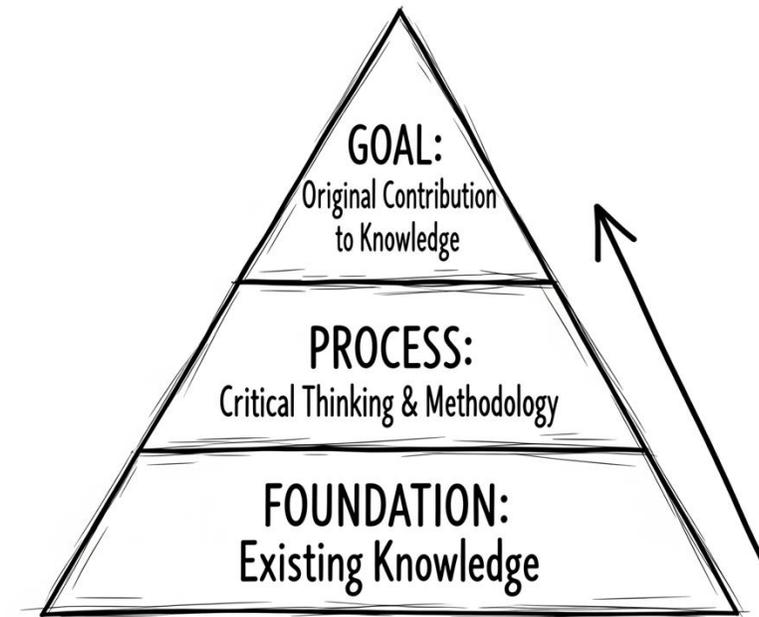
AI vs. Human intelligence

Aspect	AI	Human Intelligence
Data processing	Fast with large datasets	Slower, but flexible
Creativity	Limited, follows programmed rules	High creativity
Understanding context	Hard to capture small differences	Strong contextual understanding
Ethics	Lacks emotional intelligence	Strong ethical sense
Decision making	Based on algorithms and data	Uses judgment and experience

Key values of PhD research

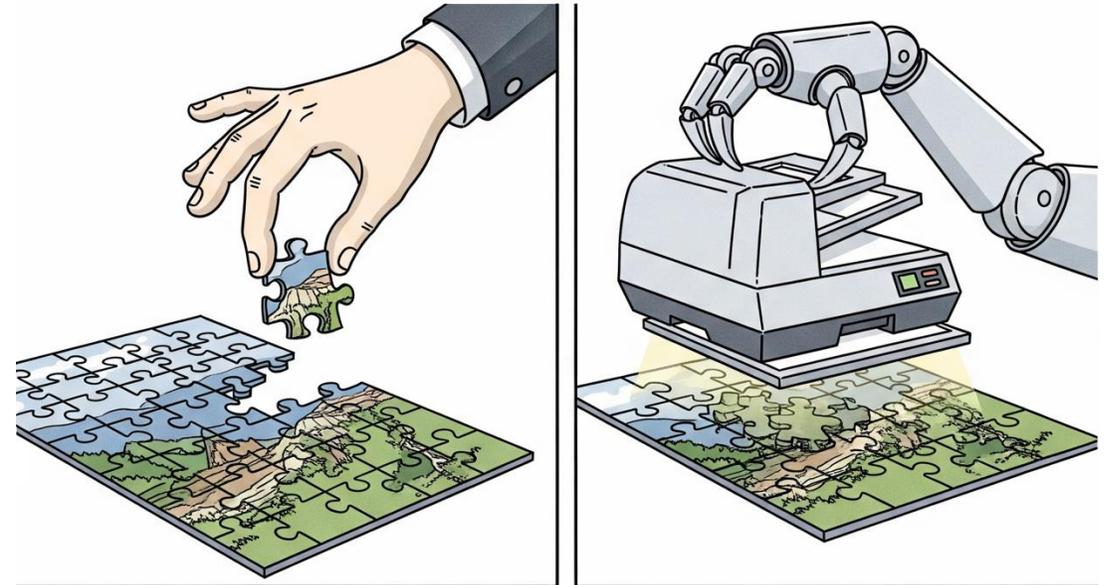
- Propose original research questions
- Develop critical thinking
- Build theoretical and methodological models
- Advance the frontiers of knowledge
- Follows ethical and academic integrity requirements

- AI has limitations in these aspects



Limitation 1 – Lack of Original Research Ability

- Relies on existing data and patterns; hard to propose new questions
- Cannot autonomously identify research gaps
- More about summarizing than innovating



Limitation 1 – Lack of Original Research Ability

Case: Urban Heat Island (UHI) Mitigation Studies

• What AI can do well

- Predicts and maps UHI patterns from satellite and land-use data
- Recognizes links (e.g., tree canopy → cooling effects, dense built-up → hotspots)
- Efficient at summarising existing relationships

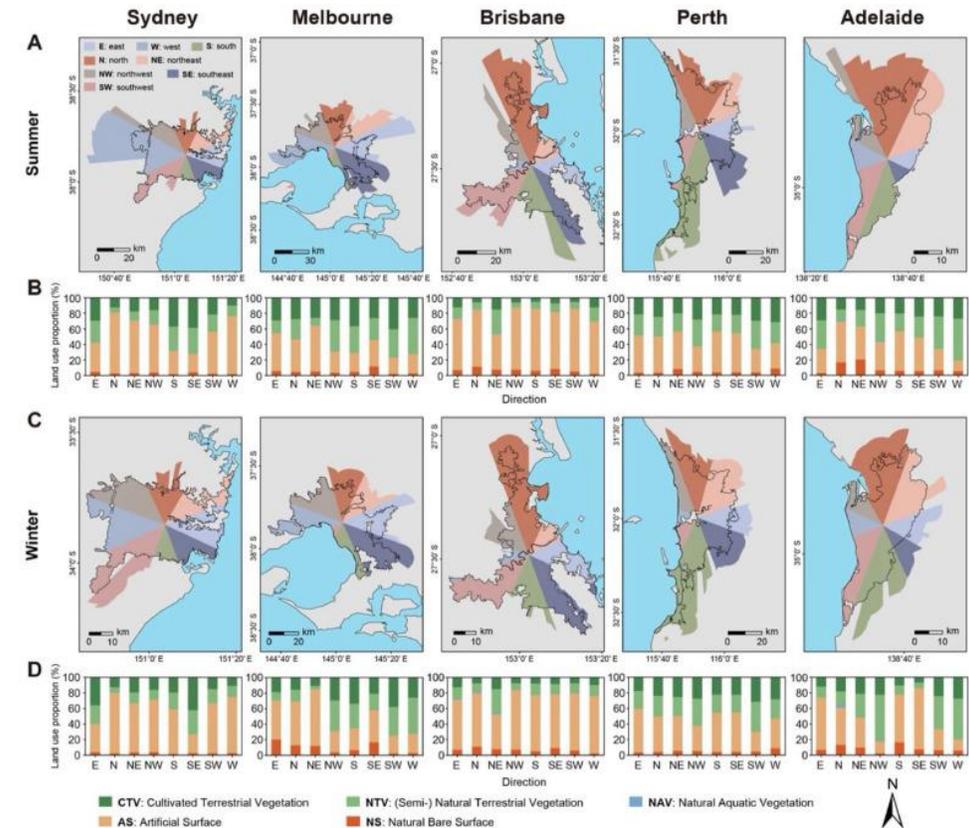
• Where AI can't do well

- Relies on existing datasets and predefined questions
- Cannot autonomously propose new research questions

• Researchers' contributions

- Novel research gaps identified by scholars, e.g.
 - Irregular anisotropy in urban heat footprints (Yang et al., 2025)
 - Urban heat vulnerability analysis and assessment of cooling strategies (Li et al., 2024)

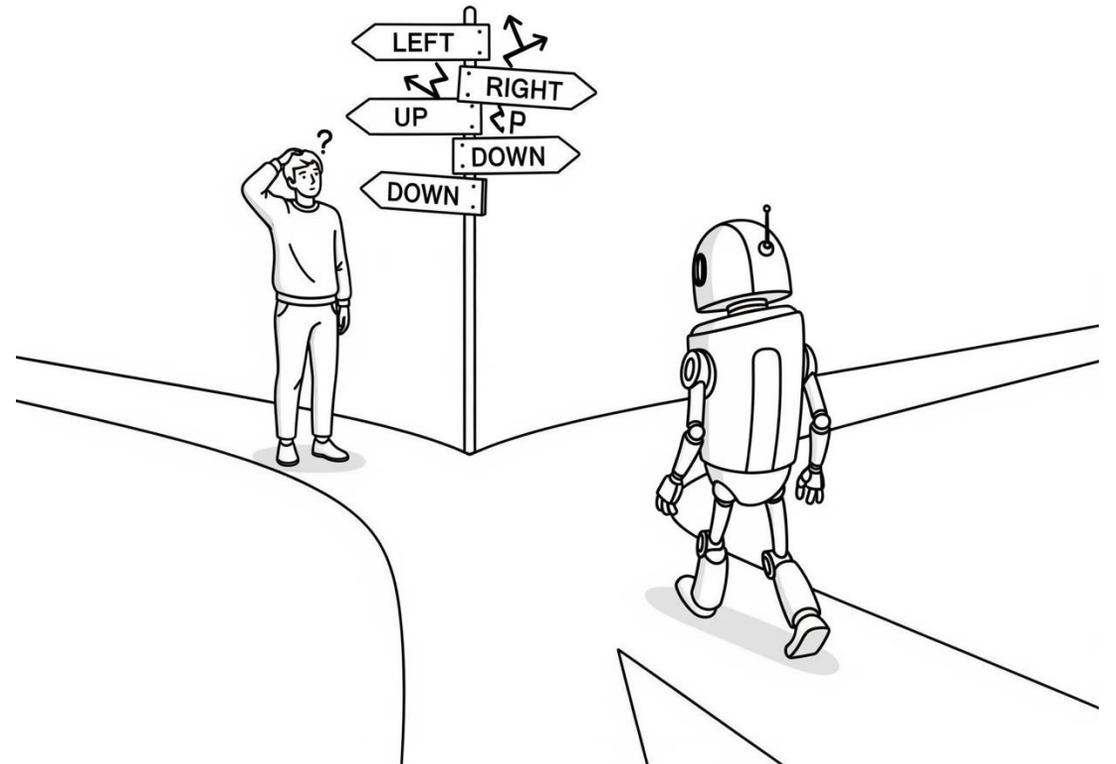
- AI enhances efficiency in summarising data, but innovation in identifying new questions from practice for sustainable cities depends on researchers.



(Yang 2025)

Limitation 2 – Lack of Critical Thinking and Creativity

- Cannot actively challenge or refute ideas
- Tends to generate “plausible-looking” text
- Tends to follow mainstream perspectives, ignoring alternative or marginalised views.
- Limited ability to handle academic debates or deep logic



Limitation 2 – Lack of Critical Thinking and Creativity

Case: Sustainable transport and mobility planning

• What AI can do well

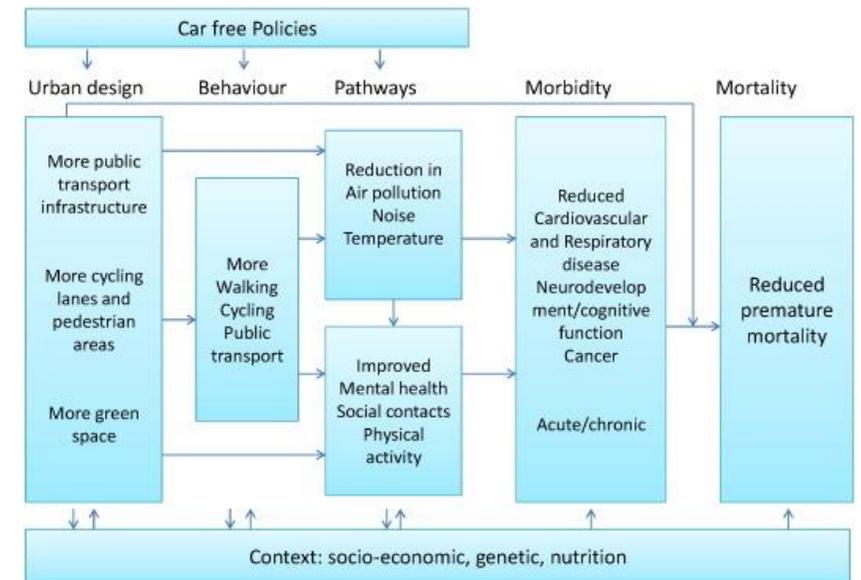
- Summarizes mainstream solutions (e.g., AI for mobility studies using big data, expand public transit, adopt electric vehicles)
- Reinforces existing narratives without questioning assumptions

• Where AI can't do well

- Challenge existing ideas
- Engage in academic debates

• Researchers' contributions

- Car-free cities have potential to reduce pollution, enhance public health, and support climate mitigation (Nieuwenhuijsen 2016)
- Hamburg, Oslo, Helsinki, and Madrid have recently announced their plans to become (partly) private car free cities.
- Other cities like Paris, Milan, Chengdu, Masdar, Dublin, Brussels, Copenhagen, Bogota, and Hyderabad have measures that aim at reducing motorized traffic including implementing car free days.



(Nieuwenhuijsen 2016)

Limitation 3 – Insufficient Disciplinary Depth & Judgment

- Limited understanding of interdisciplinary complexity
- Lacks sensitivity to disciplinary traditions and theory evolution
- Cannot replace human judgment in fieldwork or experimental design

Limitation 3 – Insufficient Disciplinary Depth & Judgment

Case: Life cycle assessment (LCA) in sustainable building design

- **What AI can do well**
 - Automates large-scale data processing (materials, energy, carbon factors)
 - Quickly generates life cycle carbon or energy estimates
- **Where AI can't do well**
 - Lacks disciplinary variations in LCA theory
 - Misses interdisciplinary judgment across engineering, environmental science, and social contexts
- **Researchers' contributions**
 - LCA of waste-integrated concrete bricks and roof tiles requires expert judgment in allocation methods, waste material qualification, and system boundary choices (Patrisia 2025)
 - LCAs on recycled versus natural aggregate concrete needs expert judgment in defining functional units, system boundaries, allocation rules, and durability considerations (Xing 2023)

Table 2
Cradle-to-gate environmental impact of 1 m³ of concrete containing RA only.

Research	ADP (kg Sb eq.)	ADP_ff (MJ)	AP (kg SO ₂ eq.)	EP (kg PO ₄ ³⁻ eq.)	GWP (kg CO ₂ eq.)	ODP (kg CFC-11 eq.)	POCP (kg C ₂ H ₄ eq.)
(Marinković et al., 2010)		1613.02–1922.62	2.07–2.29	0.12–0.15	319.63–342.70		0.07–0.09
(Pradhan et al., 2019)	2.14E-4	2940.99–3002.05	1.67–1.71	0.20	539.31–553.35	8.97E-6–9.13E-6	0.06
(Tošić et al., 2015)		1641.50–1722.97	2.15–2.24	0.13	335.66–348.28		0.06–0.07
(Kurda et al., 2018)		1530–1970			330–363		
(Marinković et al., 2017)		1778.18	1.73	0.27	266.27	3.47E-7	0.09
(Jiménez et al., 2015)	3.20E-4–4.24E-4	1820–2200	0.94–1.15	0.20–0.25	381–403	7.71E-6–9.23E-6	0.04
(Fraj and Idir, 2017)	0.54–0.72	2630–3400	0.45–0.60	0.04	245–334	8.68E-9–9.76E-9	0.02–0.03
(Xing et al., 2022)	1.61E-4–1.96E-4	1384.17–1789.69	1.19–1.51	0.20–0.26	395.77–515.65	4.77E-6–6.40E-6	0.03–0.04

Limitation 4 – Misinformation

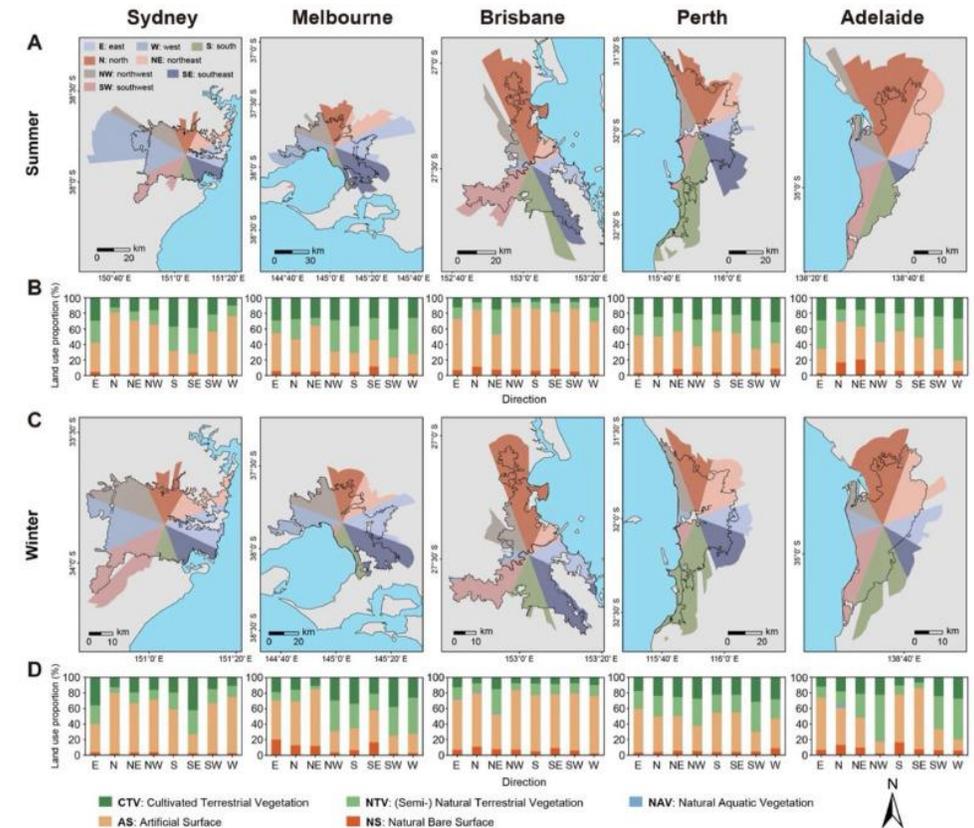
- Generates plausible but incorrect or fabricated responses.
- Cannot fact-check like humans, making it prone to spreading errors.
- **References often (always) contain mistakes (authors, dates, titles), lowering reliability.**

Limitation 5 – Ethical and Academic Integrity Issues

- May produce false citations or risk plagiarism
- Misuse of AI can threaten research quality and integrity

Conclusion and takeaways

- AI is a tool, not a substitute
- HDR research needs independent thinking and innovation
- AI can efficiently summarise existing data, but **professional experience, disciplinary depth, and researchers' judgment** remain irreplaceable in **urban and sustainability research**, such as proposing new questions in urban heat island studies, challenging paradigms in sustainable transport planning, and making decisions in life cycle assessment of building materials.



(Yang 2025)

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