Mapping Intelligibility: Hybrid AI, Sustainability, and "Wind Maps" of Singapore

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1. Introduction

In 2021, a Franco-Singaporean consortium launched the "DesCartes Program", a five-year, large-scale research project on "intelligent modelling for decision-making in critical urban systems" [1].

DesCartes practices a novel "hybrid" approach to AI, combining physics knowledge, machine learning, and human-centric and responsibility principles. Hybrid AI, DesCartes argues, can address the limitations of conventional AI-making and smart urbanisms, like environmental uncertainties, the over-reliance on "big data", and questions of responsibility [1].

One visible outcome of DesCartes is its wind map of Singapore's Marina Bay: a digital twin — a synchronized virtual representation of real-world systems — that maps air flows for civil, industrial, and environmental applications. DesCartes' wind map, for example, can monitor pollutant dispersions and forecast its implications on public health and city management [1].

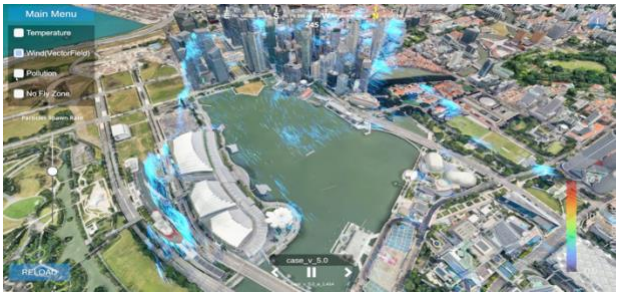

Fig. 1: DesCartes' wind map of Singapore's Marina Bay, with the blue reed-like visuals for wind flows.

Yet, air, or wind, presents a paradox due to its inherent intangibility. The nature of wind eludes steady measurement and management. In contrast, Singapore's sustainability and responsibility goals appear more concrete. Published in 2019 and 2021, respectively, Singapore's Model AI Governance Framework and Green Plan 2030 outline national objectives to responsibly harness AI and achieve net-zero emissions [2, 3].

While DesCartes' wind map appears aligned with these national plans, it also raises important questions of their practicalities. Under hybrid AI, how do DesCartes researchers collect and interpret wind in frugal, accurate, legible, and responsible ways? Similarly, how does DesCartes' organizational order [4, 5] shape such practices?

Against this backdrop, we explore how DesCartes researchers have mediated or could mediate between various techno-scientific conditions, organizational arrangements, and national visions when building their wind map.

Utilizing ethnographic methods and document analysis, we show how such negotiations — from uneven data exchanges and visual idioms for wind currents to project organization — are critical considerations when making responsible AI for intangible phenomena in urban and sustainable contexts.

2. Hybrid AI and Digital Twins

With origins in NASA's Apollo 13 mission in 1970, digital twins are virtual replicas of real-world entities and phenomena. Data from these systems is looped to the digital twin, therefore offering insights of their conduct to decision-makers [6, 7, 8].

Digital twins for urban contexts, however, are limited by inaccessible user interfaces, data unavailability, legal regulations, and the social invasiveness and economic costs of urban sensing [6, 7, 8].

In response, DesCartes enacts hybrid AI to conceive hybrid twins, the technology behind its wind map [8, 9]. DesCartes' wind map thus tracks anthropogenic and atmospheric phenomena via surrogate and interpretable modelling techniques. Moreover, by being physics-based, the wind map can operate more on "small real data" and fewer (but strategically-placed) sensors.

3. Green Plans and Responsible AI

If measured against the Singapore Green Plan 2030, DesCartes' wind map can hypothetically optimize green urban designs and support climate adaptations [3]. However, the Green Plan reveals the interpretations that DesCartes researchers must contemplate. For example, one of the Green Plan's "City in Nature" goals is to ensure households are within 10-minute strolls from green spaces [3]. Consequently, DesCartes researchers should estimate wind patterns around neighbourhoods, translating them into tangible social value. This can be information that helps users identify walkable routes or planners to further utilize wind corridors in their green designs.

Likewise, the ephemerality of wind demands inferences that present questions of responsibility. As DesCartes' hybrid AI bridges physics-based, data-

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driven predictions with social realities, Singapore's Model AI Governance Framework can anchor the interpretations inherent in wind-mapping.

Under the AI Governance Framework's conceptions of "responsibility", "explainability", and "data provenance" [2], DesCartes researchers should reasonably make clear to stakeholders how particular winds and areas are selected and computed. Concomitantly, while "fairness" [2] is framed in spatial or demographic terms, DesCartes' wind map could track how certain neighbourhoods — due to their differing socio-economics and urbanization — are more vulnerable to monsoon-related gusts and pollution drifts. A fair approach should reflect these temporal, socio-economic, and urban disparities.

4. Making and Practicing the Wind Map

Ethnographies of science have unpacked the personal, social, political, ethical, and organizational dynamics of knowledge production [4, 5, 10, 11]. DesCartes' outcomes, then, depend significantly on its researchers' problem-solving, narrative-forming, hierarchies, and more.

When creating the wind map, DesCartes' researchers tackled various dilemmas. To portray wind legibly to users, noisy visual idioms were avoided. Inspiration eventually and partially came from Japanese anime's sharp stylizations of air. "[The wind] moved like reeds," one researcher recalled of the anime they had watched. Such creativity, although not exactly "scientific standard", provides engaging glimpses into mapping intangible phenomena.

As a decision-making, human-in-the-loop tool, DesCartes researchers sought to make their wind map coherent and intuitive through virtual reality headsets and minimalist user interfaces. Ironically, the researchers found that donning the headset frustrated several users, which their minimalist interface hoped to additionally alleviate.

Echoing a major constraint of digital twins, DesCartes researchers lacked the real-world data that industry and government possessed. In some cases, data reportedly did not exist for all parties. "Data is a nice concept," a senior figure joked of its disparate ground reality. Bridging this gap, DesCartes researchers generated their own physics-based synthetic data for the wind map. Leading members also sought partnerships across Singapore's and France's private and public sectors, navigating through their governing and political bureaucracies. Both endeavours — data and partnership — thus reinforced the utility and narrative of DesCartes' hybrid AI paradigm.

In addition, many DesCartes researchers have been alert to the potential risks and stakes of their wind map. For instance, one researcher, situated midstream of the development process, expressed resistance to working on the map if it was deployed for autonomous passenger drones. For this individual, the ethical and legal liabilities of such a fraught application [12] would prove "too much to bear".

These sentiments highlight a challenge for a project's organizational order [5] and its vision of responsibility. In DesCartes, several of the wind map's researchers have described working in silos, unfamiliar with how their work mapped onto wider project plans. Such modular divisions of labour could engender "dislocated accountabilities", where individuals recognize their work's potential harms or slippages, but lack agency to address them [13]. How a project is organized — at inception or in practice — can therefore affect its notion of responsibility, as well as its prospective alignment with responsibility guidelines, like Singapore's AI Governance Framework and its recommendations of robust internal structures and value incorporation [2].

5. Conclusion

DesCartes' wind map of Singapore's Marina Bay illustrates how hybrid AI can both meaningfully support visions of sustainability and responsible AI and reveal the challenges of their ground implementation. Translating air and wind into a digital twin involves interpretive and operational steps that balance the competing and complementary imperatives of techno-scientific accuracy and adaptation, data availability and exchange, personal creativity and values, organizational structures and institutional relationships, and policy, technical, and narrative alignment.

Ultimately, DesCartes' wind map reminds us that AI-making need not be only focused on utilitarian applications, but also must consider the interpretive and operational complexities that require transparency, accountability, and creativity in mapping intangible phenomena.

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