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INDUSTRY 4.0: DIGITAL TWINS AND ACCOUNTABILITY

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Introduction

Digital twins (DTs) are often characterized as the NextGen smart cities, as part of cyber-manufacturing processes (Lee et al. 2016) and as industry 4.0 (Royko 2017). DTs are digital replicas of 'real' world physical assets, with by-directional feedback loops between the digital and the material (NAP 2024). DTs are generally discussed in IT and engineering academic literature and by vendors, uncritically, and are marketed as a real-time immersive experience, where avatars interact with others in an urban landscape, and where urban planners provide the public a view of the 'real' impact of planning decisions. Technologically solutionist rationales offer efficiently automated building operations; streamlined design and prototyping processes; and the means to monitor, predict, and preempt the impact of climate change (WGIC 2022). This paper discusses preliminary observations from an archival and AI research project examining the Imagining Canada's Digital Twin (ICDT) project (CIMS n.d. b) for the architecture, engineering, construction and owner operated (AECOO) sector.

Research Question

The authors ask: if DTs intermediate and automate actions and decisions that affect people and property, how ought records about those actions, decisions and processes be managed and archived? Can AI/ML enable that preservation, and how would one archive the AI/ML processes within a DT?

The Digital Twin Study

These questions guide the study of ICDT at Carleton University by the Carleton Immersive Media Studio (CIMS) funded by the New Frontiers in Research Grant (CIMS n.d. b). The research is part of the International Research on Permanent Authentic

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Records in Electronic Systems (InterPARES) the I Trust AI project, funded by Social Science Humanities and Research Council (SSHRC) led at the University of British Columbia. The research is framed by four interrelated theoretical approaches: critical data studies, which accepts that data and technological systems are never independent from the institutions, systems, tools, techniques and systems within which they are created and used (Kitchin & Lauriault 2018); digital diplomatics (Duranti 2009) which is "the study of the creation, form, and transmission of records, and their relationship to the facts represented in them and to their creator, to identify, evaluate, and communicate their nature and authenticity" (SAA n.d.); social and technical assemblage theory (Kitchin & Lauriault 2018) which ontologically defines a specific complex data and technological system by identifying and describing the loosely coupled context and content attributes of its making to better describe how knowledge, forms of thought, actors, legalities and governmentalities, organizations, standards among others come together to create that system. And finally, digital records forensics (Diamond 1994 in Duranti 2009) whereby the researcher becomes an expert witness of records to testify that they have not been tampered with and are authentic. Records here may be data, software, code, AI/ML, automated processes, hardware, agreements, contracts, seals and how these come together in a DT to inform actions and decisions that affect both social and material outcomes. It is about identifying what constitutes records in an evidentiary and juridical context to assess who the responsible and accountable actors are in a DT, and to test whether and what can be preserved in institutional digital archives.

Preliminary Observations

ICDT was created for the AECOO sectors and actors with the subjectivities of builders, construction supply chain management, facilities and plant managers, researchers and geographic information systems (GIS), building information modeling (BIM) and internet of things (IoT) specialists. As they are emergent, there are few standards, interoperability is a challenge, there are struggles between the owners of large monopolistic proprietary platforms and communities developing interoperable open-source systems. There is also a skills divide between facilities and plant management (FMP) that manages physical assets, architects and builders who use BIMs while FMP does not; between FMP and researchers and companies that install and maintain sensors including analytics companies that generate intelligence from them, and the revolving door of graduate students, researchers and contractors. From a juridical perspective, there is a host of undocumented agreements between asset owners and researchers; BIM procurement contracts do not stipulate data ownership; and subcontracts with sensor and analytics providers lack grounded data and technological knowledge. Currently there are no a-is BIMs as that was not stipulated in contracts; the ownership of sensor data is unclear as the sensor company is different from the company that does the analytics. We also discovered that sensors and analytics are outsourced for insurance reasons, as there is concern of automated action leading to material loss. While research is ongoing, we see systems deployed in the absence of coordinated data and technological governance. What is certain is that ICDT, while innovative and best in show, does not resemble the simple IT, engineering, building operation and vendor diagrams. We also see that records are intricately related to

juridical actors and contractual obligations; we do not yet see the evidentiary trail of automated and AI/ML actions.

Methodological Approach

A hybrid methodological case study approach that combines technological walkthroughs (Light et al. 2018) to capture the attributes of the DT was conducted with actors involved in ICDT construction, with a digital diplomatics informed semi-structured interview instrument that guided data collection. Actors include FMP, architects, IoT experts, DT project managers and archivists. We met GIS experts, the City Archivist and the building permit office, and building and operations sensor and data analytics companies. We recorded interviews and collected documentation. We inventoried software, hardware and data types, and are modeling data flows to identify code related to automation and AI/ML.

This approach enabled us to unearth contractual agreements and juridical actors and that there is no bi-directional DT, but there are multiple systems of systems under the authority of different juridical authorities within the University and the City. In terms of subjectivities, researchers at CIMS are interested in the digital rendering of the built environment, FMP is responsible for the safe operations of physical assets, researchers at the Building Performance Research Centre are interest in FMP data, the permit office ensures that building codes are met but do not process BIMs, and BIMs are not connected to the City's DT which also has no bi-directional feedback but like ICDT is a 3D interactive spatial data infrastructure for planning and scenarios. The City archives is interested in building permits and administrative records related to the City's assets, but not the DT as it is not a record but a visual publication of records. The University archives is interested in the records related to contracts, the procurement of BIMs, and of weekly status reports from the companies that read and report sensor data and not ICDT.

Conclusion

This transdisciplinary, international and cross-sectoral research conducted with critical data studies scholars, theoretical digital archivists, AI/ML scholars, records managers and archivists developed a hybrid theoretical framework and methodological process to study fledging large and complex social and technical urban DTs. Our objectives are threefold: to assess how DTs intermediate and automate actions and decisions that affect people and property, and how records about those actions, ought to be governed; to assess whether AI/ML can enable the preservation of urban DTs and if AI/ML processes can be archived and to better understand the subjectivities of actors building DTs, that may become public infrastructures thus necessitating accountability and transparency in decision making in DT records.

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