DATA-DRIVEN A-TYPE

FLOW SS24

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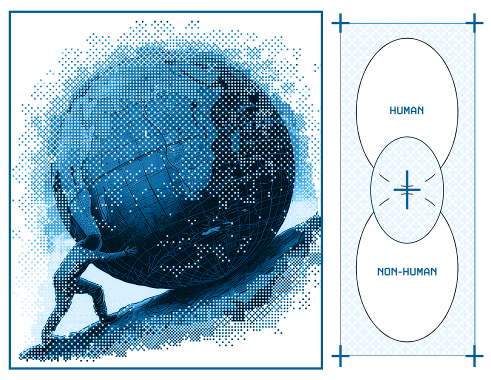

Introduction

In the Anthropocene epoch, characterized by significant human impact on the environment, we witness rapid technological advancements and a complete digitalization of our world. These changes have fundamentally altered our lifestyles and interactions. Among the most pivotal structures for our digital existence are data centers, which have traditionally operated at the fringes of human-centric spaces. As our reliance on digital infrastructure grows, these centers have become central to managing and processing the vast amounts of data necessary for modern urban operations. This thesis explores the evolution of a new architectural typology, the urban data center—termed 'Data-Driven A-Type'—through the innovative use of artificial intelligence (AI), affirming the increasing multimodality and complexity of architecture as a discipline.

Anthropocene to Post-Anthropocene Shift

The Anthropocene era has led to significant environmental changes, necessitating a transition to a more harmonious relationship with nature. This thesis examines the shift from the Anthropocene to the post-Anthropocene from the perspective of technological progress and its environmental impact. Leveraging technological advancements is essential to transitioning to the post-Anthropocene era. Subsequent technologies designed to mitigate and normalize environmental impacts are necessary to progressively minimize the overall environmental impact through continuous technological innovation. Innovations in renewable energy, sustainable agriculture, and ecological restoration are pivotal in facilitating this transition. The development of digital technologies and the Internet of Things (IoT) further enables more efficient resource management and monitoring of ecological systems.

Architecture and Data Centers

Data centers are integral to managing and processing the vast amounts of data necessary for modern urban operations. These facilities, which stand devoid of human presence, have become central to functions ranging from traffic management and public safety to energy distribution and waste management. Data centers are compared to ancient libraries, highlighting their significance in storing and processing data integral to modern life. They are becoming cultural landmarks of the digital age, symbolizing our shift into a fully digitalized society. However, the rapid growth of the data center industry has led to significant environmental concerns due to substantial energy consumption and resultant carbon footprint. This thesis discusses the challenges and opportunities of integrating data centers into urban environments.

Data Center Challenges

Data centers face significant challenges related to energy consumption, environmental impact, and the need for advanced cooling systems. Sustainable practices and innovative cooling methods are essential to address these issues. The cooling systems employed in data centers include conventional air conditioning, chilled water air handlers, liquid cooling, free cooling using outside air, hot aisle/cold aisle containment, and raised floor cooling. Each method has its advantages and limitations in terms of energy efficiency and environmental impact. This thesis explores these cooling methods in detail and examines how they can be optimized for better performance and sustainability.

Urban Integration

Integrating data centers into urban environments is crucial for the development of smart cities. Urban data centers (UDCs) should be conceptualized as multifunctional spaces that support various urban functions such as traffic management, public safety, energy distribution, and waste management. This integration goes beyond their traditional utilitarian functions, incorporating them into the social, economic, and environmental tapestry of smart cities. By blending data centers seamlessly into the urban fabric, we can create smarter cities that are capable of real-time data processing and efficient management of urban operations.

Decentralized Data Networks and Edge Computing

Decentralized data networks distribute storage and processing across multiple nodes, enhancing data accessibility, redundancy, and security. By eliminating single points of failure, decentralized networks boost system resilience and reliability. Edge computing processes data closer to its source, reducing latency and bandwidth usage, which is crucial for real-time applications like autonomous vehicles and smart traffic systems. This thesis explores the integration of decentralized data networks and edge computing to optimize data flow and enhance system resilience. By deploying local nodes throughout city buildings, we can minimize data transmission distances, reduce latency, and improve application performance.

Heat Reuse and Sustainability

Reusing waste heat from data centers for urban farming, district heating, and other applications promotes sustainability and reduces environmental impact. This thesis discusses various examples of heat reuse, such as using waste heat for greenhouse heating, district heating, swimming pool and spa heating, aquaculture, and industrial processes. These applications demonstrate the potential for data centers to contribute to urban sustainability and energy efficiency. Integrating UDCs with urban farming infrastructure offers numerous benefits, including a continuous supply of fresh produce throughout the year and a significant reduction in environmental impact associated with traditional farming and food logistics.

Public Realm and Configurable Spaces

The integration of UDCs into urban landscapes should include public spaces, green spaces, and recreational facilities. These multifunctional spaces contribute to the urban fabric, promoting public acceptance and understanding of advanced technologies. Designing UDCs with flexibility and scalability allows them to adapt to changing technological demands and spatial requirements. By incorporating mixed-use elements such as public spaces, green spaces, and recreational facilities, UDCs can serve their primary technological functions while contributing to the urban environment.

Methodology

The research involves designing and implementing UDCs using artificial intelligence to create sustainable and adaptable architectures. The methodology includes location structure generation, building massing, discrete assembly, dataset finalization, dataset samples representation, and robotic system configuration. The shift from modularity to AI and the learning process of machine learning models are also explored. This approach ensures that UDCs are designed to meet current technological demands and anticipate future requirements, embodying principles of sustainability, adaptability, and efficiency.

In conclusion, the Data-Driven A-Type concept represents a paradigm shift in the design and implementation of urban data centers. By integrating advanced computational methods, sustainable design principles, and the practical application of AI, this research provides a comprehensive framework for further developing cooperation between architectural disciplines and artificial intelligence.