Empowering Digital Humanism in Smart Built Environments through SOLID Data Spaces

Abstract

The built environment significantly influences people's health, comfort, and productivity. With the rise of IoT and integration of AI solutions in smart environments, buildings have evolved into complex ecosystems, interacting with inhabitants and surrounding systems. Two challenges arise: a knowledge gap in understanding inhabitant behavior's impact on building systems and the need to address privacy concerns in AI-enabled environments. This research aims to explore these challenges through the lens of digital humanism, focusing on creating semantically enabled data spaces based on SOLID framework to model occupants' behavior, ensure privacy, and enhance communication between inhabitants and building services.

Keywords

Data Spaces, Digital Humanism, Smart Built Environment

1. Introduction

People spend a large portion of their time inside buildings. The so-called smart built environment have been suggested to have the capacity to dynamically respond to the needs and preferences of their occupants and enhance the state of their health and comfort, while simultaneously optimizing buildings' energy and environmental performance [1]. In such environments, every interaction leaves behind a digital footprint, comprising a trail of data that reflects individuals' activities, preferences, and behaviors. From sensors tracking movement patterns to AI algorithms analyzing personal preferences, the digital footprint of humans in smart environments is intricate and pervasive. While this data holds immense potential for enhancing user experiences and optimizing systems, it also raises significant privacy concerns. In context of IoT-enabled environments, the proliferation of smart devices allows for the capture and sharing of a wide array of sensitive and private data about occupants. However, occupants frequently find themselves with limited control over their data and remain unaware of the collection, storage, and analysis processes that their data undergoes. Despite the inherent privacy risks, occupants continue sharing their data, encountering what is often termed a 'privacy paradox' and compensating for the privacy risks with the convenience offered by smart environments [2]. In other words, the benefits of customization and services offered by smart environments are weighed against consideration of digital humanism perspective [3], that strives to embed values such as human dignity, freedom, and autonomy in the digital domains. As such, balancing the benefits of data-driven insights with the protection of individual privacy is crucial for fostering trust and ethical use of technology in smart environments.

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In this context, we argue in the present contribution that, to effectively harness the potential of smart building systems, fundamental issues related to information access, privacy concerns, and data security must be addressed both conceptually and technically. In our work, we put forward the idea of an innovative computational application, which we shall refer to as LIGO (after the Latin expression for to tie, to bind, to interlink). LIGO is conceived to facilitate the negotiation between data spaces representing individual building users on the one side and data spaces representing SBS on the other side, whereby digital humanism principles (predominantly privacy and information integrity of the building users) are to be considered and built in. The proposed framework sets out ambitious goals, including:

- Bridging the digital gap in modelling occupants' presence, perception, and behaviour in buildings while accounting for and accommodating their vital data sharing and privacy requirements.
- Bridging the communication and interoperability gaps between building information models and AI-enabled services by incorporating provenance and compliance verification mechanisms for inhabitants.
- Enabling the occupants to actively, selectively, and dynamically filter the flow of information from their data space to that of the smart building systems.
- Enabling the SBS data space to provide the users with timely, effective, and intuitively understandable information about the building, its operational status, the degrees of freedom for control actions, and general orientation.

To realize these goals and address the technical challenges, we aim to leverage the Solid framework as a communication channel between the built environment and its occupants. In this paper, we present the ontological background of the proposed framework and a preliminary technical specification of the elements required for its implementation.

2. Digital Humanism

Digital technologies have a profound impact on every aspect of our modern life, from social interactions and work environments to political systems and cultural norms. While the advent of digitalization offers unique opportunities, it also triggers significant concerns regarding fundamental aspects of human existence, including dignity, autonomy, and privacy. In response to these challenges, Digital Humanism has emerged as a guiding vision, offering an alternative to technology-driven approaches to digitalization. Its overarching aim is to address various concerns and side effects that arise in the wake of transformative digital processes. Originating in Vienna, Digital Humanism finds its roots in the collaborative efforts of researchers from diverse fields, spanning social sciences, humanities, and computer science. The result of these collaborative efforts was the publication of the well-known position paper, the "Vienna Manifesto on Digital Humanism," [4] which has garnered widespread recognition and support. The manifesto underscores the importance of prioritizing human values and well-being amidst the relentless march of technological advancement. Central to the principles of digital humanism is the idea that technology should empower individuals, foster inclusivity, and promote social justice. It emphasizes the importance of considering the diverse needs and perspectives of

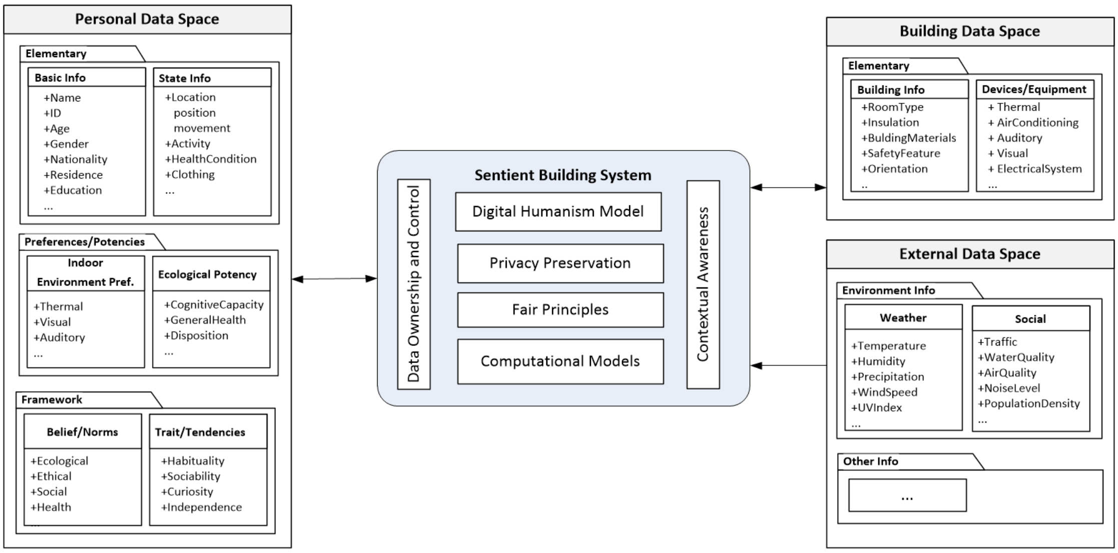

Figure 1: Schematic illustration of envisioned LIGO framework

people from all walks of life, ensuring that technological solutions are accessible, equitable, and respectful of human rights [3].

3. Proposed Framework

The core components of our proposed solution (LIGO framework) are semantically enabled data spaces, namely personal, building, and external data spaces as depicted in Fig. 1.

With regard to the configuration and operational aspects of smart buildings, theoretical foundations and technical knowledge in mechanical, structural, and electrical engineering domains are well established. Starting off from these, Building Information Modelling (BIM) [5] approaches provide the core ontological framework for creating the building data space (BDS). Matters are somewhat more complex in the case of the necessary theoretical and ontological conditions for creating and operationalizing data spaces related to building users (occupants). There are a number of behavioural theories relevant to occupants' perception of and actions in built environments [6], but the translation of those into the building operation domain has not been sufficiently accomplished [7]. In order to realize the LIGO vision, our data space ontology will reuse the occupant-centric theory of building control systems and occupant behavior and the derivative OTTO ontology [8].

The LIGO framework serves as a mediator between user-side data spaces (representing individual building users) and SBS-side data spaces (representing building situation and condition). As depicted in Fig. 2, the main components of LIGO frameworks are as follows: (i) The Personal Data Space (PODS) component pertains to individuals' personal data and encompasses basic user information, including individual attributes, needs, capabilities, and preferences (e.g., comfort and auditory preferences). Within the LIGO framework, PODS will also feature an 'access control' mechanism, allowing for the selective granting of permissions to share data

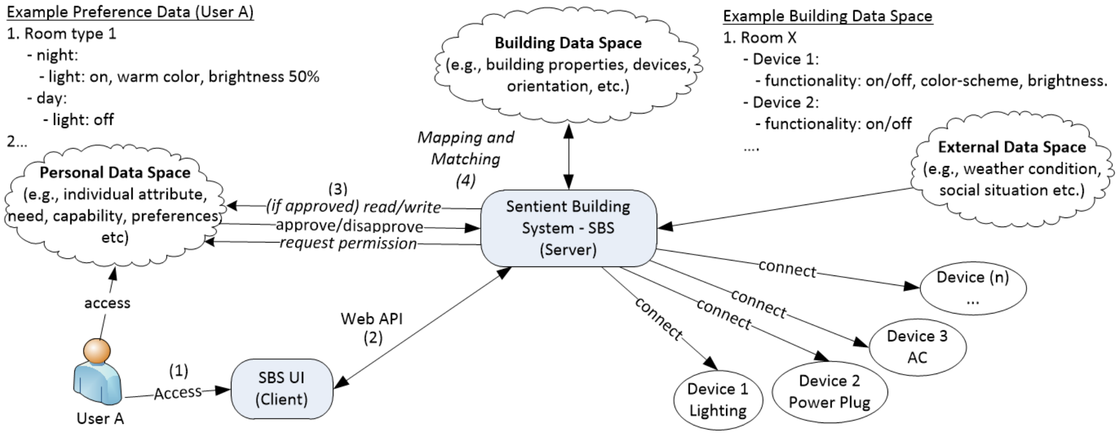

Figure 2: Elements of the envisioned LIGO architecture (personal, building, and external data spaces and the SBS server)

with the SBS. (ii) The Building Data Space(BDS) component pertains to information related to general building information and services (e.g., building and device properties, orientation etc.). (iii) The External Data Space (EDS) component represents relevant external information (e.g. weather condition, social situation, climate information, etc.) (iv) The Smart Building System (SBS) component leverages the digital humanism model embedded within LIGO data spaces, enhancing contextual awareness in building processes and facilitating tailored service recommendations. (v) The SBS User Interface (SBS-UI) this component serves as "end-user app" that makes it possible for users to seamlessly interact with SBS and share their personal data. It communicates with SBS server though Web API and provides control in using the SBS system.

4. Outlook

The key motivating factor behind the present contribution was the perception of a critical gap between: i) the increasing potential of big data, AI, IoT, and cloud computing to facilitate the creation and operation of smart built environments on the one side, and ii) the reservations toward fully embracing such technologies due to concerns (privacy, security, freedom of choice, and dignity) formulated, among other places, in the digital humanism manifesto. In this paper, we provided an overview of an ongoing development to facilitate user-controlled, safe, and secure communication between building occupants and smart building system. Ongoing efforts aim at implementing the related concept of the LIGO platform based on SOLID framework and make it fully operational, and test it for consistency, stability, robustness, and user experience.

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