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Digitalisation in the Built Environment: Challenges and Opportunities

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Dig-IT Lab Publications

Interdisciplinary collaborative research to reduce the environmental impact of buildings through digitalisation

Introduction

The Dig-IT Lab competence centre aims to leverage the potential of digitalisation throughout the life cycle of buildings, promoting sustainable practices within the industry. The centre focuses on the development and implementation of digital twins, which are virtual representations of physical buildings that enable real-time monitoring, analysis, and optimisation. The Dig-IT Lab fosters collaboration between academia and industry partners, bringing together expertise from diverse stakeholders, including building owners, technology providers, research institutions, and consultants. The centre aims to develop practical solutions and disseminate knowledge through workshops, conferences, and educational programmes, ultimately driving the adoption of sustainable practices and digital innovation within the built environment.

This paper present results from an interview study with the centre partners conducted in October and November 2023.

The paper presents 48 main challenges and opportunities related to digitalization in the built environment. The main themes revolve around developing AI-driven solutions for fault detection, predictive maintenance, and optimising building operations, alongside exploring innovative business models for these technologies. Significant attention is given to data sharing, legal frameworks, and standardisation to facilitate collaboration and interoperability between building owners, technology providers, and research institutions. Ultimately, the aim is to create a smarter, more efficient, and sustainable built environment through digitalisation.

Method

This study employed a semi-structured interview design to gather qualitative data from participants about their perspectives on the collaboration with Dig-IT Lab (Fejes & Thornberg, 2009). Semi-structured interviews were chosen to allow for flexibility in exploring participants' insights, while still focusing on key research questions. The interviews were conducted between October and November 2023.
The participants were the centre partners in Dig-IT Lab. In total, 13 companies/organizations and 24 participants were interviewed.
Interviews were conducted per centre partner, with each session lasting approximately 60 minutes. The interviews were held either in-person or via video conferencing, depending on participant availability. A set of open-ended interview questions was used to guide the discussions. The key questions included:

- What are the main challenges that you would like to investigate through Dig-IT Lab?
- What do you hope to achieve from the collaboration in general?
- What is your vision and your "business model," so that we can align and create a win-win situation?
- What are your expectations of KTH in general, and Dig-IT Lab specifically?

These questions were designed to explore participants' goals, challenges, and expectations for the collaboration with Dig-IT Lab. Follow-up questions were used to further probe responses and clarify key points as necessary. The interview data was transcribed

and analyzed using thematic analysis, dividing the responses into eight categories: 1) Business Models and Value Creation, 2) Collaboration and Knowledge Sharing, 3) Education and Skills Development, 4) Infrastructure and Data Management, 5) Legal and Ethical Considerations, 6) Organisational Impact and Digital Transformation, 7) Services and Applications, and 8) Standardisation and Interoperability. This method was chosen to identify and examine patterns within the responses.

Results

This paper examines various areas of interest related to digitalisation in the built environment. The interviews identified a wide range of topics and concerns raised by the centre partners.

Business Models and Value Creation

The interviews highlight the need to investigate and develop new business models that leverage AI and digitalisation in the built environment. This includes exploring the added value of AI in areas like fault detection and predictive maintenance. Key questions revolve around ownership and operation of systems, responsibility boundaries between technology providers and building owners, and data sharing models. The development of Key Performance Indicators (KPIs) is also emphasised to measure the effectiveness of products and certifications.

Collaboration and Knowledge Sharing

The interviews stress the importance of collaboration to foster synergies, facilitate development, generate ideas, and expand networks. This includes using physical spaces as showrooms and living labs to demonstrate and test digital solutions. Sharing ideas, software, and knowledge within the centre is also crucial. The development of collaborative federated AI and community involvement are highlighted.

Education and Skills Development

The interviews identify the need to utilise digitalisation initiatives for internal education and research and development purposes. Increasing interest in digitalisation is seen as vital for attracting more students and developing long-term competence in the field. There is a need to educate facility managers and operators on how to use new digital services and AI.

Infrastructure and Data Management

The interviews call for the creation of a neutral digital testbed that enables AI training, reference implementations for R&D, digital twin simulations, and benchmarking for optimisation companies. There is a desire to connect building management systems (BMS), Internet of Things (IoT) devices, and spatial data models. Integration of external data sources like weather and traffic information with building data is also desired. The interviews acknowledge the need to investigate and improve asset management systems, which are seen as lagging behind in digitalisation.

Legal and Ethical Considerations

The interviews raise concerns about legal issues and ethics related to AI, fault detection, and applications. Developing legal structures that facilitate data sharing and access to premises is emphasised. This includes sharing data through open platforms.

Organisational Impact and Digital Transformation

The interviews recognise the need to address the weak competence and low knowledge about buildings within facility management organisations. Understanding user perspectives in relation to AI is highlighted. A key challenge is to engage the entire organisation in digitalisation efforts. The interviews explore how digitalisation can impact organisations and working practices, including the necessary skills and new ways of working.

Services and Applications

The interviews also identified the need of sandboxing and pilot projects to train companies and test products and software. There is interest in enabling software and "apps" to control various building functions and exploring the outsourcing of operations. Development of visualisation tools for key areas and advanced analysis of property data, including economic performance, complaints, and environmental factors are also mentioned. The sources express a need for tools to extract information from buildings and explore how autonomous systems, like delivery systems, can access building spaces.

Standardisation and Interoperability

The importance of agreeing on standards within consortia is highlighted, including shared tag lists and operational procedures. Existing collaborations should be continued and industry standards like REC and BRICK should be investigated. Connecting different data models and ontologies like AFF, REC, and BRICK is seen as important for predictive maintenance and fault management. Reducing integration time between different systems from vendors like IDUN, Schneider, and Siemens is a priority. The development of APIs in platforms like IDA for AI is suggested.

Table 1 – Main challenges and opportunities related to digitalization in the built environment

Nr.	Subject	Main challenges and opportunities related to digitalization in the built environment
1	Business Models and Value Creation	Develop AI functions, smartness in systems to minimize workload.
2	Business Models and Value Creation	Investigate added value of AI (fault detection, predictive maintenance etc.)
3	Business Models and Value Creation	Business models related to AI, fault detection, apps etc.
4	Business Models and Value Creation	Business models, selling products or services?
5	Business Models and Value Creation	Retrofit and business models for Building Management systems (BMS): Traditionally BMS is not updated when refurbishing buildings. The result is decreased security and integration problems.
6	Business Models and Value Creation	Discuss who own/operate systems, discuss responsibilities, boundaries. Technology provider vs building owner.
7	Business Models and Value Creation	Data market layer, business logic, legal, case can be sharing economy, how can such a thing look like? How, for example, premises can be shared between permanent owners.

8	Business Models and Value Creation	Develop KPI:s related to products, what works, what is not working well etc. Also for certifications.
9	Collaboration and Knowledge Sharing	Case: how to share data between buidling owners, and universities.
10	Services and Applications	Packaging, selling/buying of recycled products/materials.
11	Legal and Ethical Considerations	Climate impact and digitalization. Increased amount of sensors and data vs increased building performance.
12	Collaboration and Knowledge Sharing	Collaborate to enable synergies, development help, get ideas, networking.
13	Collaboration and Knowledge Sharing	Using DIL as a showcase, meeting place, show room
14	Collaboration and Knowledge Sharing	Sharing ideas, software, knowledge within the centre
15	Collaboration and Knowledge Sharing	Visibility, to be part of ongoing development related to digitalization.
16	Collaboration and Knowledge Sharing	Develop collaborated federated AI, community development
17	Education and Skills Development	Use DIL internally for education, for accessing internal R&D
18	Education and Skills Development	Increase interest for digitalization in order to get more students, and in the long term more competence
19	Education and Skills Development	Educate facitlity managers/operators how to use new services/AI
20	Education and Skills Development	Validation of company:s ways of working, critical evaluation
21	Infrastructure and Data Management	Create a neutral digital testbed, enabling training of AI. Reference implementation enabling R&D. Digital twin, simulator for benchmarking optimization companies.
22	Infrastructure and Data Management	Would like to connect BMS, IOT and spatial data/models. Would like to get external data (weather, traffic etc.) and combine with building data.
23	Infrastructure and Data Management	Investigate asset management systems and digitalization, they are currently lacking behind
24	Legal and Ethical Considerations	Legal issues and ethics related to AI, fault detection, apps etc.
25	Legal and Ethical Considerations	Develop legal structures that enable easy sharing and access to data, and premises. Sharing data in/through an open platform
26	Infrastructure and Data Management	Develop behavior part of the digital testbed, get it into IDA/ICE.
27	Organisational impact and Digital Transformation	Organization, facility management, today weak competence, low knowledge about buildings. How to digitalise
28	Organisational impact and Digital Transformation	User perspectives in relation to AI
29	Organisational impact and Digital Transformation	Problem of getting the whole organization interested in digitalization.
30	Organisational impact and Digital Transformation	How can digitalization impact our organization and ways of working? What new competences are necessary, what new ways of working will digitalization lead to.
31	Infrastructure and Data Management	Connect buildings to enable smart cities
32	Services and Applications	Enable virtual sensing, fault detection, state estimation and model predictive control
33	Services and Applications	Sand boxing/Pilotes within DIL, train companies and the product/software
34	Services and Applications	Enabling that sofware, "apps" can control everything, also that operation can be outsourced
35	Services and Applications	Develop visualization for specific key areas.
36	Services and Applications	Develop advanced analysis of property data, economy, complaints, environments etc.
37	Services and Applications	Interested in finding tools for extracting information from buildings
38	Services and Applications	Autonomous systems, how can they (delivery systems for example) get access to space for delivery? Short term access for specific reasons.
39	Services and Applications	Battery control
40	Services and Applications	Autodiscovery of for example sensors and systems

41	Services and Applications	Apps for increased customer value
42	Standardisation and interoperability	Agree on standards within the consortium, shared tag lists. Investigate REC and BRICK. Continue existing collaboration within the Swedish real estate sector
43	Standardisation and interoperability	Connect AFF and Ontology (REC and Brick). Connection important for predictive maintenance, fault notifications/complaints,
44	Standardisation and interoperability	Decrease time for integration, between for example ProptechOS, Schneider, Siemens.
45	Standardisation and interoperability	Develop API in IDA for AI
46	Standardisation and interoperability	Shared information model
47	Infrastructure and Data Management	Companies have buildings that can be used for R&D
48	Organisational impact and Digital Transformation	Companies can support with knowledge how property owners think. Economically, organization, technology

Concluding remarks

This paper explores key aspects of digitalisation in the built environment based on industry interviews. A major focus is on developing AI-driven business models, particularly for predictive maintenance and fault detection, while addressing system ownership, data sharing, and performance measurement. Collaboration and knowledge sharing are essential, with emphasis on living labs, federated AI, and industry-wide cooperation.

Education and skills development are critical, highlighting the need to train facility managers and attract students to the field. Infrastructure improvements include creating a neutral AI testbed, integrating IoT with building management systems, and enhancing asset management. Legal and ethical concerns focus on AI governance, fault detection, and open data-sharing frameworks.

Organisational challenges include low digital competence and the need to engage entire teams in transformation efforts. The study also explores sandboxing projects, AI-driven building management applications, and automation in property operations. Standardisation and interoperability remain key, with a focus on aligning industry standards and improving system integrations.

Overall, the study highlights AI, collaboration, and innovation as essential to advancing digital transformation in the built environment.

References

Fejes, A., & Thornberg, R. (2009). *Handbok i kvalitativ analys*. Liber.