LDAC2023
11th Linked Data in Architecture and Construction Workshop

Proceedings of the 11th Linked Data in Architecture and Construction Workshop (LDAC 2023)

Matera, Italy, June 15-16, 2023

Walter Terkaj, María Poveda-Villalón, Pieter Pauwels (eds)
Support

Diamond sponsors:

Gold sponsors:

Silver sponsors:
Organisational support:
Preface

The LDAC workshop series provides a focused overview on technical and applied research regarding the usage of semantic web, linked data and web of data technologies for architecture and construction (design, engineering, construction, operation, etc.). The workshop aims at gathering researchers, industry stakeholders, and standardization bodies of the broader Linked Building Data (LBD) community. The aim of the workshop is to present current developments in research and development, coordinate efforts, gather stakeholders, and extend industry uptake and collaboration.

We are pleased to collect in this volume the papers that were submitted and presented during the 11th Linked Data in Architecture and Construction (LDAC) Workshop. The workshop took place on 15 and June 2023, as a stand-alone event in Matera, Italy. The workshop was preceded by an extensive 3-day summer school. The workshop hosted fifteen full papers, 3 short papers, and 8 industry submissions. Full and short papers were reviewed by the members in the program committee, and industry submissions were reviewed by the LDAC team. All submissions, including industry submissions can be found in these proceedings.

The workshop also included three excellent keynote on three diverse topics, one of them hosted during the SSoLDAC Summer School. The first keynote, by Michela Mortara (CNR – IMATI Genova) was titled “Shape and Semantics for urban modelling – the role of geometry in city digital twins”. This keynote talk described an overview of computer graphics approaches to construct a digital 3D representation of an urban context from real data. This includes the identification of salient elements and linking semantic information to their geometric counterparts. Examples of use cases that the geometric layer of the urban digital twin can answer to were discussed from ongoing projects with Matera and Catania.

The second keynote was given by Danh Le Phuoc (TU Berlin), with the title “Connect Sensors to Perception via Semantic Stream”. In this talk, Prof. Le Phuoc presented how to use semantic streams to connect sensory data to perception systems for robots, drones or cars to understand their surroundings, e.g roads, buildings and physical objects. An explanation is given of how semantic and episodic
memories are represented as semantic and stream graphs to integrate and fuse various kinds of sensory observations, e.g., images, videos and point clouds, into interlinked sub-symbolic and symbolic data streams at different levels of semantic abstractions.

The third and last keynote was presented by Prof. Francesca Lisi (Università degli Studi di Bari "Aldo Moro"), with the title “Data-driven AI vs. Model-driven AI: Which one should we trust more?”. Artificial Intelligence (AI) is currently gaining an increasing attention, also from the media, thanks to an impressive number of successful applications in a wide variety of domains. This keynote talk discusses there recent developments in AI, showing also their limits, in particular the presence of bias - the presence of undesirable prejudices and stereotypes in the data - and where it comes from. In extension, an overview is given of some of the ethical guidelines for a trustworthy AI that were recently defined by the AI High-level Expert Group of the European Commission. It is expected that the most interesting AI applications are yet to come, and will rely on the combination of data-driven and model-driven approaches.

Acknowledgments

This event is only possible by dedicated and committed support from several organisations and people. In particular, we thank the authors and presenters for their high-quality contributions, the Program Committee who reviewed the papers presented in this volume, the keynote speakers for their excellent contributions, and the local organisers, in particular Walter Terkaj and Sara Arlati, for all organizational efforts.

Special thanks go to the sponsors of this workshop, with bSDD and Pallas as diamond sponsors, Neanex, OntoText, AEC3, Building Digital Twin Association (BDTA), BimConnected, Amberg Group, and Tennet as gold sponsors, and Basilicata Creativa as silver sponsor.
Program Committee

- Jakob Beetz, RWTH Aachen, Germany
- Calin Boje, Luxembourg Institute of Science and Technology, Luxembourg
- Mathias Bonduel, Neanex Antwerp, Belgium
- Nicolas Bus, Centre Scientifique et Technique du Bâtiment, France
- Andrea Cimmino, Technical University of Madrid, Spain
- Goncal Costa, Ramon Llull University, Barcelona, Spain
- Aaron Costin, University of Florida, United States of America
- Alex Donkers, Eindhoven University of Technology, Netherlands
- Diellza Elshani, University of Stuttgart, Germany
- Paola Espinoza Arias, Universidad Politécnica de Madrid, Spain
- Raúl García-Castro, Technical University of Madrid, Spain
- Philipp Hagedorn, Ruhr-University Bochum, Germany
- Al-Hakam Hamdan, A+S Consult GmbH, Germany
- Cheong Hyunmin, Autodesk Research, Canada
- Felix Larrinaga Barrenechea, Mondragon University, Spain
- Maxime Lefrancois, École des Mines de Saint-Étienne, France
- Dimitris Mavrokapnidis, University College London, United Kingdom
- Thamer Mecharnia, École des Mines de Saint-Étienne, France
- Nandana Mihindukulasooriya, IBM Research AI, Ireland
- Claudio Mirarchi, Politecnico di Milano, Italy
- Jyrki Oraskari, RWTH Aachen, Germany
- Pieter Pauwels, Eindhoven University of Technology, Netherlands
- Ekaterina Petrova, Eindhoven University of Technology, Netherlands
- María Poveda-Villalón, Technical University of Madrid, Spain
- Dimitrios Rovas, University College London, United Kingdom
- Ana Roxin, University of Burgundy, Dijon, France
- Georg Schneider, Schaeffler Technologies AG, Germany
- Oliver Schulz, RWTH Aachen, Germany
- Madhumitha Senthilvel, RWTH Aachen, Germany
- Alvaro Sicilia, Ramon Llull University, Barcelona, Spain
- Daniele Spoladore, Consiglio Nazionale delle Ricerche, Italy
- Ranjith Soman, ETH Zürich, Switzerland
- Walter Terkaj, Consiglio Nazionale delle Ricerche, Italy
● Edlira Vakaj, Birmingham City University, United Kingdom
● Jeroen Werbrouck, Ghent University, Belgium

Local Organising Committee

● Walter Terkaj, Consiglio Nazionale delle Ricerche (CNR), Italy
● Sara Arlati, Consiglio Nazionale delle Ricerche (CNR), Italy
● Lucio Tommaso de Paolis, Università del Salento, Italy
● Ugo Erra, Università della Basilicata, Italy

LDAC Committee

● Walter Terkaj, Consiglio Nazionale delle Ricerche, Italy
● María Poveda-Villalón, Technical University of Madrid, Spain
● Pieter Pauwels, Eindhoven University of Technology, Netherlands
● Alex Donkers, Eindhoven University of Technology, Netherlands
● Jeroen Werbrouck, Ghent University, Belgium
● Madhumitha Senthilvel, RWTH Aachen, Germany
# Table of contents

## Regular Papers

*Linked data for the life cycle assessment of built assets*
Calin Boje, Sylvain Kubicki, Tomas Navarrete Gutierrez, Thomas Beach  
11 – 22

*Lessons Learned from Designing and Using bcfOWL*
Oliver Schulz, Jyrki Oraskari, Jakob Beetz  
23 – 34

*Towards usable ICDD containers for ontology-driven data linking and link validation*
Philipp Hagedorn, Madhumita Senthivel, Hans Schevers, Lucas Verhelst  
35 – 46

*dstv: An ontology-based extension of the DSTV-NC standard for the use of linked data in the automation of steel construction*
Lukas Kirner, Jyrki Oraskari, Victoria Jung, Sigrid Brell-Cokcan  
47 – 58

*Development of a national scale digital twin for domestic building stock*
Cathal Hoare, Tareq Alqazzaz, Usman Ali, Shushan Hu, James O'Donnell  
59 – 70

*Towards a U.S. national bridge and infrastructure data dictionary: an introduction*
Aaron Costin, Marina Muller  
71 – 84

*Semantic bSDD: improving the GraphQL, JSON and RDF representations of buildingSmart data dictionary*
Vladimir Alexiev, Mihail Radkov, Nataliya Keberle  
85 – 97

*The semantic link between domain-based BIM models*
Wojciech Teclaw, Madsholten Rasmussen, Nathalie Labonnote, Jyrki Oraskari, Eilif Hjelseth  
98 – 109

*Making urban energy use more intelligible using semantic digital twins*
Sander R. de Meij, Alex J.A. Donkers, Dujuan Yang, Matthijs Klepper

110 – 122

Modular knowledge integration for smart building digital twins
Isaac Fatokun, Arun Raveendran Nair, Thamer Mecharnia, Maxime Lefrançois, Victor Charpenay, Fabien Badeig, Antoine Zimmermann

123 – 138

Metadata schema generation for data-driven smart buildings
Lasitha Chamari, Joep van der Weijden, Lolke Boonstra, Stefan Hoekstra, Ekaterina Petrova, Pieter Pauwels

139 – 150

Don’t Shoehorn, but Link Compliance Checking Data
Ruben Kruiper, Ioannis Konstas, Alasdair J.G. Gray, Farhad Sadeghineko, Richard Watson, Bimal Kumar

151 – 163

Validation of building models against legislation using SHACL
Emma Nuyts, Jeroen Werbrouck, Ruben Verstraeten, Louise Deprez

164 – 175

WE-TEST: Leveraging word embeddings and transformers to extract semantics from building regulations text
Odinakachukwu Okonkwo, Amna Dridi, Edlira Vakaj

176 – 188

Terrestrial laser scanning for surveying and 3D modelling of underground built heritage: A case study of hypogea in the Sassi of Matera
Nicla Maria Notarangelo, Nicola Capece, Gilda Manfredi, Nicodemo Abate, Nicola Masini, Aurelia Sole Ugo Erra

189 – 200

Short Papers

Learning partial correlation graph for multivariant sensor data and detecting sensor communities in smart buildings
Xiang Xie, Manuel Herrera, Tejal Shah, Mohamad Kassem, Philip James

201 – 211

Linked data for a construction big data platform
Davide Simeone

212 – 221
Taking stock: a Linked Data inventory of Compliance Checking terms derived from Building Regulations

Abstracts

Asset information management for a communications network in Ireland
Aonghus O’Keeffe, David Torrado 238 – 238

bhOWL: BHoM with semantic web technologies
Alessio Lombardi, Diellza Elshani, Thomas Wortmann, Al Fisher 239 – 239

An open endpoint and framework for the development of linked data for building energy systems
James Allan, JongGwan An, Reto Fricker, Sascha Stoller, Philipp Heer 240 – 240

Exploring the benefits of semantic web technologies for providing holistic end of life analysis of civil infrastructure in the Netherlands
Esra Bektas 241 – 241

Graph and graphics: combining two powerhouses into one machine
Philipp Dohmen, Emmanouil Argyris, Markus Färber, Michael Reebing 242 – 242

Semantic rules for generating SPARQL from semantic mark-up
Nick Nisbet, Zijing Zhang 243 – 243

Implementing and managing mappings for data transformation using SHACL Rules
Lucas Verhelst 244 – 244

Semantisation of rules for automated compliance checking
Edlira Vakaj, Maxime Lefrançois, Amna Dridi, Thomas Beach, Mohamed Gaber, Gonçal Costa Jutglar, He Tan 245 – 246