JOWO 2019
The Joint Ontology Workshops

Proceedings of the Joint Ontology Workshops 2019
Episode V: The Styrian Autumn of Ontology

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Edited by

Adrien Barton | Selja Seppälä | Daniele Porello

and for

BOG | CAOS IV | CREOL | DAO-SI | FOMI | FOUST III |
ODLS | SHAPES 5.0 | SoLEE | WINKS-2 | WODHSA | WOMoCoE

http://www.iaoa.org/jowo/2019/

JOWO Workshops

T. Hahmann, R. Peñaloza, S. Schulz, G. Guizzardi, O. Kutz, N. Troquard	**(BOG)**
O. Kutz, M. M. Hedblom, G. Righetti, D. Porello, C. Masolo	**(CAOS IV)**
V. Basile, T. Caselli, D. P. Radicioni, A. A. Ravelli	**(CREOL)**
A. Mosca, R. Confalonieri, D. Calvanese	**(DAO-SI)**
M. Gruninger, W. Terkaj	**(FOMI)**
A. Galton, S. Borgo, O. Kutz, F. Loebe, F. Neuhaus	**(FOUST III)**
M. Boeker, L. Jansen, F. Loebe, S. Schulz	**(ODLS)**
S. Borgo, I. Hinterwaldner, O. Kutz, R. Stufano Melone	**(SHAPES 5.0)**
L. Jansen, M. Brochhausen, N. Guarino, G. Guizzardi, D. Porello	**(SoLEE)**
A. Kemo, J. Euzenat, D. Gromann, E. Jiménez-Ruiz, M. Schorlemmer, V. Tamma	**(WINKS-2)**
M. Nicolosi Asmundo, R. Ferrario, E. M. Sanfilippo	**(WODHSA)**
S. Borgo, L. Bozzato, T. Mossakowski, A. Zimmermann	**(WOMoCoE)**

PREFACE

JOWO – The Joint Ontology Workshops

These proceedings include the papers presented at JOWO 2019, the fifth edition of the Joint Ontology WOrkshops (JOWO). JOWO is a venue of workshops that, together, address a wide spectrum of topics related to ontology research, ranging from cognitive science to knowledge representation, natural language processing, artificial intelligence, logic, philosophy, and linguistics. JOWO's mission is to provide a platform for the diverse communities interested in building, reasoning with, and applying formalised ontologies both in theory and applications. The previous editions of the JOWO series were the following:

- The first JOWO edition was 'Episode I: The Argentine Winter of Ontology', held in Buenos Aires, Argentina, in co-location with the 24th International Joint Conference on Artificial Intelligence (IJCAI 2015). The proceedings of JOWO 2015 appeared as volume 1517 of CEUR.[1]
- The second JOWO edition was 'Episode II: The French Summer of Ontology', held in Annecy, France, in co-location with the 9th International Conference on Formal Ontology in Information Systems (FOIS 2016). The proceedings of JOWO 2016 appeared as volume 1660 of CEUR.[2]
- The third JOWO edition was 'Episode III: The Tyrolean Autumn', hosted by the Free University of Bozen-Bolzano in Bolzano, Italy, in September 21–23, 2017. The proceedings of JOWO 2017 appeared as volume 2050 of CEUR.[3]
- The fourth JOWO edition was 'Episode IV: The South African Spring (JOWO 2018 @ FOIS 2018)', held in Cape Town, South Africa, in co-location with the 10th International Conference on Formal Ontology in Information Systems (FOIS 2018). The proceedings of JOWO 2018 appeared as volume 2205 of CEUR.[4]

JOWO 2019 comprised a confederation of twelve ontology workshops and five tutorials.

The workshops covered a broad spectrum of contemporary applied ontology research, including its foundational aspects (FOUST III), its methodology and quality evaluation (BOG, WOMoCoE), the link between ontologies and data science (DAO-SI), the application of ontologies in specific domains, in particular, cognitive science (CAOS IV), contextual representations of information (CREOL), industry (FOMI), life sciences (ODLS), the concepts of shape, form and structure (SHAPES 5.0), social, legal and economic domains (SoLEE), digital humanities (WODHSA), and knowledge sharing (WINKS-2).

[1] See http://ceur-ws.org/Vol-1517/.
[2] See http://ceur-ws.org/Vol-1660/.
[3] See http://ceur-ws.org/Vol-2050/.
[4] See http://ceur-ws.org/Vol-2205/.

The tutorials also covered a wide variety of topics ranging from foundational ontologies (FOUNT, TLO), ontology engineering (DOnEReCA), and machine learning with ontologies (MLwO), to biomedicine (SNOMED).

We were very happy to include in our program three keynote speeches by Antony Galton, Yongsheng Gao, and Valentina Presutti, who focused on several aspects of fundamental and applied ontology research.

A total of 101 papers were submitted to the workshops of which 83 were accepted.

These proceedings document the twelve JOWO 2019 workshops and the abstracts of the five tutorials and the three keynote talks:

Workshops

- **BOG**: 2nd International Workshop on Bad or Good Ontology[5]
- **CAOS IV**: Cognition And OntologieS[6]
- **CREOL**: Contextual Representation of Objects and Events in Language[7]
- **DAO-SI**: Data meets Applied Ontologies in Open Science and Innovation[8]
- **FOMI**: 10th International Workshop on Formal Ontologies meet Industry[9]
- **FOUST III**: Workshop on Foundational Ontology[10]
- **ODLS**: Ontologies and Data in Life Sciences 2019[11]
- **SHAPES 5.0**: The Shape of Things[12]
- **SoLEE**: Ontology of Social, Legal and Economic Entities[13]
- **WINKS-2**: Second Workshop on INteraction-based Knowledge Sharing[14]
- **WODHSA**: 1st International Workshop on Ontologies for Digital Humanities and their Social Analysis[15]
- **WOMoCoE** : 4th International Workshop on Ontology Modularity, Contextuality, and Evolution[16]

[5]See http://bog.inf.unibz.it.
[6]See http://caos.inf.unibz.it.
[7]See https://creol2019.di.unito.it.
[8]See https://daosi.inf.unibz.it.
[9]See http://stl.mie.utoronto.ca/fomi2019/home.html.
[10]See http://foust.inf.unibz.it.
[11]See https://wiki.imise.uni-leipzig.de/Gruppen/OBML/Workshops/2019-ODLS.
[12]See http://www.loa.istc.cnr.it/workshops/SHAPES5/.
[13]See https://solee-2019.github.io.
[14]See http://www.iiia.csic.es/winks-2/.
[15]See http://www.loa.istc.cnr.it/WODHSA/.
[16]See https://womocoe19.fbk.eu.

Tutorials

- **DOnEReCA**: Data-driven ontology engineering with Relational Concept Analysis[17]
- **FOUNT**: Towards a systematic methodology for foundational ontologies: properties, relations, and truthmaking
- **MLwO**: Semantic similarity and machine learning with ontologies[18]
- **SNOMED**: SNOMED CT Tutorial
- **TLO**: Top Level Ontologies (ISO/IEC 21838)

Keynotes

- Antony Galton, **Theories of Time and Temporality: A Guided Tour for Ontologists**
- Yongsheng Gao, **Insights into Large-Scale Ontology Production**
- Valentina Presutti, **ArCo: the Knowledge Graph of Italian Cultural Heritage**

[17] See http://gdacweb.info.uqam.ca/donereca/.
[18] See https://github.com/bio-ontology-research-group/ontology-tutorial.

Acknowledgements

We would like to thank all authors and speakers for their contributions, and the programme committee members and additional reviewers for their timely reviewing. Moreover, we would like to thank the International Association for Ontology and its Applications (IAOA)[19], SNOMED International[20], and Das Land Steiermark[21] for providing generous financial support and facilities.

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[19] See http://iaoa.org.
[20] See www.snomed.org.
[21] See www.verwaltung.steiermark.at.

JOWO 2019 Workshops

BOG

2nd International Workshop on Bad or Good Ontology

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As ontologies are used in more domains and applications and as they grow in size, the consequences of bad ontology design become more critical. Bad ontologies may be inconsistent, have unwanted consequences, be ridden with anti-patterns, or simply be incomprehensible. In general, bad ontologies present design mistakes that make their use and maintenance problematic or impossible.
Programmers have had access to various tools, such as debuggers or linters, to help identify stylistic errors, suspicious constructs, or logical errors, to avoid bad program design. Similar methods and tools are needed for ontology engineering.
This workshop series aims to bring together research on all aspects concerning bad or good ontology design, including use cases and systematic reviews of bad or good ontology designs, techniques and tools for diagnosing, explaining, and repairing bad ontologies, and approaches or benchmarks for evaluating such techniques.
The main topics addressed by the workshop are the following:

- systematic analysis of ontologies for symptoms of bad ontology design
- cataloguing of symptoms of bad ontology design

- methods for detecting or explaining symptoms
- metrics and methods to gauge ontology quality
- design methods that likely result in bad ontologies
- principled methods to avoid building bad ontologies
- benchmarks of bad or good ontologies for evaluating diagnostic and repair methods

CAOS IV

Cognition And OntologieS

Programme Chairs

Oliver Kutz	Free University of Bozen-Bolzano, Italy
Maria M. Hedblom	Free University of Bozen-Bolzano, Italy
Guendalina Righetti	Free University of Bozen-Bolzano, Italy
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CAOS: Cognition And OntologieS, is a workshop series devoted to the relationship between cognition and ontologies with the purpose to model, simulate and represent cognitive phenomena for artificial intelligence and knowledge representation, and to stimulate interdisciplinary exchange between these areas.
This fourth edition of CAOS, held at JOWO 2019 in Graz, follows events held at the conference Formal Ontology in Information Systems (FOIS 2016), Annecy, France, in 2016, CAOS 2 held at the AISB Convention, organised by the Society for the Study of Artificial Intelligence and Simulation of Behaviour (AISB

2017), in 2017, and CAOS 3, held at the Joint Ontology Workshops (JOWO) in conjunction with FOIS 2018 in Cape Town, South Africa.
CAOS addresses the difficult question of how key cognitive phenomena and concepts (and the involved terminology) can be found across language, psychology and reasoning and how this can be formally and ontologically understood, analysed and represented. The workshop welcomes submissions on topics related to the ontology of hypothesised building blocks of cognition (such as image schemas, affordances, and related notions) and of cognitive capacities (such as concept invention, language acquisition), as well as system-demonstrations modelling these capacities in application settings. We also welcome submissions addressing the cognitive and epistemological adequacy of ontological modelling.
CAOS aims to address an interdisciplinary audience, inviting scholars in philosophy, computer science, logic, conceptual modelling, knowledge representation, and cognitive science to contribute to the discussion.

CREOL

Contextual Representation of Objects and Events in Language

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The CREOL workshop aims at developing an interdisciplinary venue where different communities (Applied Ontology, NLP, AI, Semantic Web) can meet and investigate and share ideas, visions, theories, and frameworks on the relationship between the semantic representation of objects and events and their interpretation in context.
Dealing with context is a key factor in the conceptualisation of human experience, and thus a major issue for understanding natural language. Current ontologies

and lexicons (e.g. DOLCE, Unified Verb Index) offer limited (meaning) representations of events and objects that then may find different realisations in text. Additionally, the growing interest towards multimodal information systems requires devising approaches and resources aimed at representing context by considering different sources (e.g., textual description, image, video) as a whole.
Contextual access to objects and events needs to be investigated at its interface with language and visual scene, as well. Recently, several advanced approaches have been proposed to model meaning representations of lexical items in their context (e.g., contextualised word representations). Likewise, approaches and resources have been designed to represent and make explicit the relations intervening between objects in scenes depicting events, while established theories of meaning representation allow for the representation of context to varying extent (e.g., Abstract Meaning Representation, Discourse Representation Theory).
In the second edition of the workshop we have collected three original contributions addressing different aspects of this complex (and sometimes blurred) interface layer. Jezek (*Sweetening Ontologies Cont'd: Aligning Bottom-up and Top-Down Ontologies*) investigates the mapping of categories between DOLCE and the Typed Predicate Argument Structures (T-PASS) framework, where category labels are determined on the basis of the context of occurrence predicates and their corresponding arguments. Chow and Gruninger (*Multimodal Event Recognition with an Ontology For Cooking Recipes*) address the interrelations across different modalities (auditory, visual and textual) in the domain of cooking recipes to uncover the relationships between events by investigating the role of ontologies. Finally, Ghosh and Abdulrab (*Towards a Pattern-Based Core Model of Events in the Legal Domain*) proposes a model of events in the legal domain by building on the definition of events (perdurants) as a focusing process from scenes, defined as maximal perdurants located in a convex region of space-time containing all perdurants occurring there as parts (following the proposal by Guizzardi and Guarino (2016)).

DAO-SI

Data meets Applied Ontologies in Open Science and Innovation

Programme Chairs

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Vitalis Wiens	Enterprise Information Systems, Fraunhofer IAIS, Germany

The goal of the DAO-SI workshop was to provide opportunities for stakeholders from academia, industry, and public organisations to present their latest developments in ontology-mediated data integration, data access and analysis techniques, and data-driven applications, with a special focus on Science and Innovation (S&I) data management for decision and policy-making.
The accepted contributions, three in total, present applications of ontologies and related tools in fields like aeronautics and space, knowledge discovery from data, and ontology-based data access. In the first paper, Steven J. Hughes, Daniel J. Crichton, and Ronald S. Joyner present an ontology-mediated space science digital repository, where ontologies are used as building blocks for the information model of NASA's Planetary Data System, an information system that preserves the digital data produced by or relevant to NASA's planetary missions in an open and interoperable fashion. In another paper, Mickael Wajnberg, Petko Valtchev, Mario Lezoche, Alexandre Blondin Massé, and Hervé Panetto propose a formal concept analysis based method for multi-relational data mining able to mine conceptual abstractions on several cross-tables, and illustrate its usefulness in decision support in the industrial context of aluminum die casting. Finally, German Beaun, Laura Cecchi, and Pablo Fillottrani introduce a framework that supports the interoperation of several off-the-shelf Ontology-based Data Access (ODBA) tools and systems, which facilitate access to data sources through queries on a conceptual level.

FOMI

10th International Workshop on Formal Ontologies meet Industry

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María Poveda Villalón	Technical University of Madrid (UPM), Spain

FOMI is an international forum where academic researchers and industrial practitioners meet to analyse and discuss application issues related to methods, theories, tools and applications based on formal ontologies. There is today wide agreement that knowledge modelling and the semantic dimension of information play an increasingly central role in networked economy: semantic-based applications aim to provide a framework for information and knowledge sharing, reliable information exchange, meaning negotiation and coordination between distinct organizations or among members of the same organization. Theoretical ideas seem often very promising but their actual implementation brings up unexpected problems and issues. The FOMI 2019 Workshop deals with:

1. Experience with problems in ontology application;
2. New insights on known problematic issues;
3. New results;
4. Successes and observations in ontology implementation;
5. Lessons learned on the best way to apply ontological methodologies to real-world situations.

FOMI 2019 will facilitate open discussion and experience sharing. Very similar problems arise in disparate ontology applications and an open discussion helps to highlight commonalities and to spread ideas for possible solutions. For this reason, FOMI welcomes researchers and practitioners that embrace this perspective without restrictions on the domains they deal with: business, medicine, engineering, finance, law, biology, geography, electronics, etc. Indeed, the accepted contributions at FOMI 2019, eight in total, tackle heterogeneous topics. Three works (Gruninger and Katsumi; Guarino and Sanfilippo; Smith et al.) examine how different foundational ontologies (i.e. PSL, DOLCE and UFO, BFO) can be adopted to support the Industrial Ontologies Foundry (IOF), an initiative aimed

at developing a set of open ontologies for manufacturing and engineering industry applications. In addition, two more papers deal with the manufacturing domain, in particular manufacturing process plans (Sormaz and Sarkar) and manufacturing resources (Sanfilippo, Terkaj, and Borgo). Other specific domains are addressed like transportation planning (Katsumi and Fox) and assembly systems in aerospace industry (Arista and Mas). Finally, the work by Tan, Tarasov and Adlemo presents lessons learned from the use of ontologies in the scope of software engineering.

FOUST III

Workshop on Foundational Ontology

Programme Chairs

Antony Galton	University of Exeter, UK
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Riichiro Mizoguchi	Japan Advanced Institute of Science and Technology, Japan
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Foundational ontology is about categories of reality or thought which are common to all or almost all subject-matters. Commonly considered examples of such categories include 'object', 'quality', 'function', 'role', 'process', 'event', 'time', and 'place'. There are several foundational ontologies that provide a systematic formal representation of these categories, their relationships, and interdependencies.
Amongst existing foundational ontologies, there is both a substantial measure of agreement and some dramatic disagreements. There is currently no uniform consensus concerning how a foundational ontology should be organised, how far its 'reach' should be (e.g., is the distinction between physical and non-physical entities sufficiently fundamental to be included here?), and even what role it should play in relation to more specialised domain ontologies.
The main use of foundational ontologies is as a starting point for the development of domain ontologies and application ontologies. The foundational ontology

provides an ontology engineer with a conceptual framework that enables her to analyse a given domain, identify the entities in the domain as specialisations of the generic categories in the foundational ontology, and often reuse relationships (e.g., parthood) from the foundational ontology.
The utilisation of foundational ontologies for the development of domain and application ontologies has two main benefits. Firstly, the ontology engineer can reuse an existing set of well-studied ontological distinctions and design principles instead of having to develop an ad-hoc solution. Secondly, if two domain ontologies are based on the same foundational ontology, it is easier to integrate them.
FOUST is an ontology workshop series that offers researchers in foundational ontology an opportunity to present their results. This includes work on specific areas of foundational ontology as well as work on particular foundational ontologies. Topics covered in this edition of FOUST include, amongst others, physical features, processes, actions, functions, relations, and properties.

ODLS

Ontologies and Data in Life Sciences 2019

Programme Chairs

Martin Boeker	University of Freiburg, Germany
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Axel-Cyrille Ngonga Ngomo	Paderborn University, Germany
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Aleksandra Sojic	Institute of Biomedical Technologies, National Research Council (ITB-CNR), Italy
Holger Stenzhorn	University Hospital Tuebingen, Germany
Robert Stevens	University of Manchester, UK
Dagmar Waltemath	University of Greifswald, Germany

Medicine, biology and life sciences produce hardly manageable and often incomprehensible amounts of data, information, and knowledge. Their computer-based retrieval, processing, integration, as well as their conceptual foundation, application, and reuse present ever new challenges to existing methods of knowledge representation, data bases, and data analysis and retrieval. Data management and data processing in the life sciences and in health care demand sophisticated methods and solutions for the integration and usage of distributed, heterogeneous data.

The workshops on Ontologies and Data in Life Sciences (ODLS), of which ODLS 2019 is the 9th instance, cover the overall spectrum of biomedical information management, ranging from experimental data acquisition and preprocessing across analysis, structuring and interpretation of data, up to developing structured representations of knowledge, in particular in the form of ontologies, with their various applications. The primary aim of ODLS is an interdisciplinary exchange of ideas and results, fostering collaboration between ontologists, computer scientists, bio-informaticians, medical information scientists, physicians, biometricians, bio-chemists and philosophers, in academia and industry.

The submissions to ODLS 2019 cover a broad range of topics closely related to ontologies in the fields of biology, the life sciences, medicine, and health care, or they deal with foundational or applied aspects of such ontologies. Similarly in breadth, there is a lively mix of contributions focusing on ontological content and domain analysis, as well as of other papers that are concerned with methods and languages for representing and/or formalizing knowledge.

ODLS workshops are run by the work group *Ontologies in Biomedicine and Life Sciences* (OBML), a sub-group of a shared, interdisciplinary group associated with the *German Informatics Society* (GI) and the *German Association for Medical Informatics, Biometry and Epidemiology* (GMDS). Moreover, since their third edition the workshops have been acknowledged as Supported Events by the *International Association for Ontology and its Applications* (IAOA). The workshops are held by and large annually in Central Europe, striving for international participation beyond that region. Becoming a part of IAOA's Joint Ontology Workshops in 2019, as in 2017, supports fruitful interaction with other communities, very well in line with the interdisciplinary spirit of ODLS.

SHAPES 5.0

The Shape of Things

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Rossella Stufano	Politecnico di Bari, Italy
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Antony Galton	University of Exeter, UK
Franca Giannini	IMATI CNR, Italy
Michael Gruninger	University of Toronto, Canada
Maria M. Hedblom	Photogeniq, Austria
Kris Krois	Free University of Bozen-Bolzano, Italy
Frieder Nake	University of Bremen, Germany
Susanna Siegel	Harvard University, USA

Shape, Form, and Structure are elusive notions and yet are at the core of several disciplines from the humanistic (like literature and the arts) to the scientific (chemistry, biology, physics) and within these from the formal (mathematics, logic) to the empirical (engineering, cognitive science). Even within domains such as computer science and artificial intelligence, these notions rely on common-sense meanings and everyday perception and communication practices. Furthermore, formalisations of the semantics and reasoning about shape, form, and structure are typically ad hoc. Several approaches have been proposed within the aforementioned disciplines to study the notions of shape, form and structure from different viewpoints. A comprehensive formal view of how to understand their different uses has not emerged yet but it is clear that one needs to investigate an interdisciplinary perspective.

The Shapes workshop series is an interdisciplinary platform for the discussion of all topics connected to shape (broadly understood). Perspectives from psycholinguistics, ontology, computer science, artificial intelligence, mathematics, aesthetics, design science, cognitive science and beyond are welcome to contribute and participate in the workshop. We seek to facilitate an interdisciplinary discussion between researchers from all disciplines interested in representing shape, form and structure, and reasoning about them. This includes formal, cognitive, linguistic, engineering and/or philosophical aspects of space and vision, being the domains where shape, form and structure find a natural setting, as well as their application in the sciences and in the arts.

Every edition of Shapes adds a special theme to drive attention to particular uses and needs in interesting areas. SHAPES 5.0, the fifth edition in the series, drives attention to shape, form and structure in architecture. Architecture is an intrinsically interdisciplinary domain that nicely combines art, science and technology, and is rooted in the study of culture, landscape, territory and social practices. The study of shape, form and structure is part of the background of architects but architects tend to view and understand these notions within the context of a project design and not in their generality. We particularly encourage contributions that shed some light on the use of shape, form and structure in and across architectural works and architectural ways of thinking.

SoLEE

Ontology of Social, Legal and Economic Entities

Programme Chairs

Ludger Jansen	University of Rostock & Ruhr-Universität Bochum, Germany
Mathias Brochhausen	University of Arkansas for Medical Sciences, USA
Nicola Guarino	ISTC-CNR, Italy
Giancarlo Guizzardi	Free University of Bozen-Bolzano, Italy
Daniele Porello	ISTC-CNR, Italy

Programme Committee

Mauricio Almeida	Universidade Federal de Minas Gerais, Brasil
Frederik Elwert	Ruhr University Bochum, Germany
Roberta Ferrario	ISTC-CNR, Italy
Pawel Garbacz	KUL Lublin, Poland
Amanda Hicks	University of Florida, USA
Paul Johannesson	Royal Institute of Technology, Sweden
Riichiro Mizoguchi	JAIST, Japan
Neil Otte	Johns Hopkins University, USA
Chris Partridge	BORO Solutions, UK
Kurt Sandkuhl	University of Rostock, Germany
Tiago Prince Sales	University of Trento, Italy
Barry Smith	SUNY at Buffalo, USA

Understanding the ontological nature of social, legal and economic concepts and institutions is crucial for providing principled modelling in many important domains such as enterprise modelling, business processes, and social ontology. A significant number of fundamental concepts that are ubiquitous in economics, social, and legal sciences – such as value, risk, capability, good, service, exchange, transaction, competition, social norm, group, institution – have only recently been approached from a specifically ontological perspective. It is therefore important to offer a venue to gather the recent contributions to this topic.

The workshop encouraged submissions on both theoretical and methodological issues in the use of ontologies for modelling social, legal and economic concepts and institutions, as well as submissions on concrete use of ontologies in application for these domains. The workshop relates mainly to two previous events (SoLE-BD and Ontology of Economics 2018). We intended to broaden the focus in order to explore the emerging question of how to deal with social entities in general, and to connect well established domains like biomedicine and business ontologies in this respect.

The workshop collects approaches to deal with social, legal and economic entities in foundational and applied ontologies and discusses applications of these approaches to social, legal and economic entities in ontologies for biomedicine and business informatics.

WINKS-2

Second Workshop on INteraction-based Knowledge Sharing

Programme Chairs

Adrian Kemo	IIIA-CSIC, Spain
Jérôme Euzenat	INRIA, Université Grenoble Alpes, France
Dagmar Gromann	University of Vienna, Austria
Ernesto Jiménez-Ruiz	The Alan Turing Institute, UK & University of Oslo, Norway
Marco Schorlemmer	IIIA-CSIC, Spain
Valentina Tamma	University of Liverpool, UK

Programme Committee

Manuel Atencia	Université Grenoble Alpes, France
Paula Chocron	Insikt Intelligence, Spain
Mauro Dragoni	Fondazione Bruno Kessler, Italy
Thierry Declerck	DFKI, Germany
Tim Finin	University of Maryland, USA
Karl Hammar	Jönköping University, Sweden
Axel-Cyrille Ngonga Ngomo	University of Leipzig & University of Paderborn, Germany
Terry R. Payne	University of Liverpool, UK
Matthias Scheutz	Tufts University, USA
Katia Sycara	CMU, USA
Nardine Osman	IIIA-CSIC, Spain

This Second Workshop on INteraction-based Knowledge Sharing (WINKS-2) is aimed at researchers and practitioners investigating issues related to aspects of (autonomous) knowledge sharing, where the integration of knowledge is inherently interaction-based, irrespective of whether the interaction is machine to machine, or human to machine. Gradually expanding, distributed systems heighten the need of dynamic interactive knowledge-sharing processes and ever more sophisticated mechanisms are used to acquire and elicit knowledge. A paradigm shift has emerged that views knowledge creation, curation and evolution as a collaborative and interactive process between autonomous entities. As a highly interdisciplinary workshop, WINKS-2 invites submissions that address the fundamental issues and challenges posed by interaction-based approaches to knowledge sharing. At the same time, we are interested in submissions that provide solutions for allowing knowledge sharing interactively, with a particular focus on the processes, mechanisms and protocols underlying the proposed solution.

WODHSA

1st International Workshop on Ontologies for Digital Humanities and their Social Analysis

Programme Chairs

Marianna Nicolosi Asmundo	University of Catania, Italy
Roberta Ferrario	ISTC-CNR, Italy
Emilio M. Sanfilippo	Le Studium, Loire Valley Institute for Advanced Studies, University of Tours, France

Programme Committee

Alessandro Adamou	National University of Ireland, Ireland
Valentina Bartalesi	ISTI-CNR, Italy
Arianna Betti	University of Amsterdam, The Netherlands
Enrico Daga	The Open University, UK
Øyvind Eide	University of Cologne, Germany
Adam Fedyniuk	Nicolaus Copernicus University, Poland
Richard Freedman	Haverford College, USA
Leif Isaksen	University of Exeter, UK
Ludger Jansen	University of Rostock & Ruhr-Universität Bochum, Germany
Alessandro Mosca	Free University of Bozen-Bolzano, Italy
Albert Meroño-Peñuela	University of Amsterdam, The Netherlands
Antonella Poggi	Università La Sapienza, Italy
Giuseppe Primiero	Università degli Studi di Milano, Italy
Viola Schiaffonati	Politecnico di Milano, Italy
Daria Spampinato	ISTC-CNR, Italy
Maria Rosaria Stufano Melone	Politecnico di Bari, Italy
Perrine Thuringer	University of Tours, France
Jouni Tuominen	University of Helsinki, Finland

The International Workshop for Digital Humanities and their Social Analysis (WODHSA) gathers original research work about application and theoretical issues emerging in the elaboration of conceptual models, ontologies, and Semantic Web technologies for the Digital Humanities (DH). A plethora of heterogeneous and multi-format data – including 3D models, photos, audio records, and documents on paper – is currently available in the DH domain. Such huge amount of information retrieved from different and often isolated sources and contexts, disseminated in different places, asks for principled methodologies and technologies to semantically characterize and possibly integrate data and data models for analysis, visualization, retrieval, and other purposes. Moreover, dedicated automated reasoning tools allow to prove the consistency of data (models) and to extract implicit information thereby present to gain a deeper knowledge on the DH domain at stake. Hence, research efforts towards the application or use of reasoning engines is of vital relevance.
The WODHSA workshop also welcomes contributions that look at data, ontologies, and conceptual models for the DH from a broader philosophical or sociological perspective contextualizing them within the debate on digital technologies or models in philosophy or science and technology studies (STS). The contributions are expected to shed some light on the (social, economic, political, etc.) interests that drive the development and adoption of computer models in the DH and the impact on the involved stakeholders and society at large.

WOMoCoE

4th International Workshop on Ontology Modularity, Contextuality, and Evolution

Programme Chairs

Stefano Borgo	ISTC-CNR, Italy
Loris Bozzato	Fondazione Bruno Kessler, Italy
Till Mossakowski	Otto-von-Guericke University Magdeburg, Germany
Antoine Zimmermann	École des Mines de Saint-Étienne, France

Programme Committee

Grigoris Antoniou	University of Huddersfield, UK
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Thomas Eiter	Vienna University of Technology, Austria
José M. Giménez-García	Université Jean Monnet, France
Michael Gruninger	University of Toronto, Canada
Adila A. Krisnadhi	University of Indonesia, Indonesia
Oliver Kutz	Free University of Bozen-Bolzano, Italy
Raphael Peñaloza	University of Milano-Bicocca, Italy
Patrick Rodler	Alpen-Adria Universität Klagenfurt, Austria
Thomas Schneider	University of Bremen, Germany
Luciano Serafini	Fondazione Bruno Kessler, Italy
Vojtěch Svátek	University of Economics Prague, Czech Republic
George Vouros	University of Piraeus, Greece

In applying knowledge representation and reasoning techniques, knowledge is rarely taken as a single monolithic and static structure. Partitioning knowledge into distinct modular structures is central to organize, expand and amend knowledge bases. Also, understanding, representing and reasoning about context is essential for a correct use of knowledge modules and to correctly reason in changing situations. Finally, evolution of knowledge resources is an important factor influencing the quality and value of stored knowledge when new information is acquired.

Considering these needs, the International Workshop on Ontology Modularity, Contextuality, and Evolution (WOMoCoE) gives the opportunity to discuss current work on practical and theoretical aspects of modularity, contextuality and evolution of ontology based knowledge resources.

The workshop aims to bring together an interdisciplinary audience interested in these topics to discuss both theoretical and formal aspect, and to investigate the variety of application perspectives. WOMoCoE 2019, the 4th edition of the Workshop on Ontology Modularity, Contextuality, and Evolution, takes place in Graz on Sept. 23, 2019 within the framework of the 5th Joint Ontology WOrkshops (JOWO 2019).

The workshop is opened by a keynote by Robert Hoehndorf (*Evaluating ontology modules from the perspective of machine learning*) and continues with the oral

presentation of the four accepted contributions included in this volume. Each submitted paper was reviewed by at least three members of the program committee. As in the past, much time is dedicated to the discussion of the papers to foster active, broad and cross-disciplinary interactions.

Tutorials

DOnEReCA: Data-driven ontology engineering with Relational Concept Analysis

Organiser

Petko Valtchev — University of Quebec at Montreal, Canada
Mickael Wajnberg — University of Quebec at Montreal, Canada

Data can successfully support ontology engineering tasks such as design or maintenance. For instance, whenever an ontology is designed on top of a relational database, data can be analysed to detect significant patterns (clusters, associations...). These can witness important domain concepts, properties and rules, that might not be directly observable in the database schema. Similarly, when populating an existing ontology with independently created data, one might want to assess the mapping of data objects to ontology classes. Patterns mined from the mapped data can suggest a variety of improvements: Strong association between types and properties can indicate irregularities such as missing values for instances, or typing problems, it can also highlight missing descriptors for classes; alternatively, clusters in the data can reveal missing classes in the ontology. As a matter of fact, even ontologies with data properly integrated might benefit from this type of analysis.

Formal Concept Analysis [1] (FCA) provides a knowledge discovery framework enabling both (1) conceptual clustering of data objects and (2) pattern/association discovery. It was thought as a mathematical approach to the design of concept hierarchies (called concept lattices) from a sets of observations (introduced as object x attribute tables, called formal contexts). FCA, as most data mining approaches, focuses on a single data table. However, Linked Data typically comprise several resource types, hence such datasets are inherently multi-table, a.k.a. multi-relational.

Relational Concept Analysis [2,3] (RCA) is a multi-relational data mining [4] (MRDM) framework designed on top of FCA. To bring the mathematical strength of FCA to the realm of RDF and Linked Data, RCA admits a set of contexts, as well as context-to-context binary relations. To discover plausible concepts from such datasets, a propositionalization mechanism called scaling is used to refine object descriptions as per input contexts: OWL-inspired relational scaling operators replace inter-object links with property restriction-like attributes, called relational, that refer to concepts from the range context. Potential cycles in data are dealt with in an iterative fix-point computation that gradually expands the ordinary concept lattices with relational attributes. As RCA fix-point lattices reflect the refined contexts much in the same way as with FCA, clusters and patterns are drawn thereof by existing FCA methodologies. Cycles are, in turn, resolved by expanding concept descriptions in a minimal fashion. RCA has been applied

to practical problems from a wide range of fields such as software engineering [5], hydroecology [6], data interlinking [7], ontology learning [8].
In this tutorial, we start by bringing the audience to an understanding of the mathematical foundations of the FCA method. The notions of context, derivation, concept, concept lattice, etc. are presented together with a basic algorithm for lattice construction. Association rules and quality metrics are also presented within the framework of FCA. Next, we focus on RCA and its specific manner of processing multi-relational data: The notions of relational context family, scaling operators, propositionalization, etc. are introduced along with the iterative lattice construction method in RCA. Circular definitions in relational concept descriptions and in association rules are then exposed and our solution to dis-entangle these references discussed. An industrial use case helps illustrate these notions.
In the second part of the tutorial, the emphasis shifts to the way RCA-based tools can support ontology engineering tasks. A number of scenarios is presented involving data drawn from DBpedia. A first case corresponds to a good fit between an ontology and underlying data. Then, a method is presented that helps detect miss-typed resources or, alternatively, possible class description refinements. Next, the extraction of a draft schema from a dataset without such schema is introduced. Finally, RCA is shown to provide a framework for the restructuring/refinement of an ontological schema (with no data).

Mickael Wajnberg is a student, currently enrolled in a PhD at University of Quebec at Montreal (UQAM; Québec, Canada) and at Université de Lorraine (France), he currently works on RCA and knowledge extraction. He did a Math and Physics Prepa before he got an Engineering Degree (M.Sc. equivalent) at Telecom Nancy (France) and a M.Sc. at University of Quebec at Chicoutimi (Québec, Canada) in Computer Science, he specialized in algorithms and theory for computer science.

Dr. Petko Valtchev is Associate Professor with the Computer Science department of University of Quebec at Montreal (UQAM; Québec, Canada). His Ph.D. was awarded in 1999 by J. Fourier University, Grenoble, France. He is member of the Editorial Board of the International conference on Formal Concept Analysis (FCA) and has served as a member of the program committees of top-tier conferences (AAAI, IJCAI, ISWC). He has been researching on knowledge discovery and data mining with/from ontologies and knowledge bases. In this context, he designed a number of methods and practical tools exploiting concept analysis.

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FOUNT: Towards a systematic methodology for foundational ontologies: properties, relations, and truthmaking

Organisers

Nicola Guarino	ISTC-CNR, Italy
Giancarlo Guizzardi	Free University of Bozen-Bolzano, Italy
Daniele Porello	ISTC-CNR, Italy

Well-founded ontologies have a double role in the practice of ontology design. On the one hand, they intend to make the modeller's basic choices and assumptions clear: this is all about intended models, which need to be suitably characterized by means of logical axioms. On the other hand, they intend to make such basic choices justified and sharable among a community of users, by relying on a formal analysis of the nature and structure of the world, in terms of very general categories and relations, like object, property, relation, event, time, space, quality, modality, disposition, and so on. Nowadays, these general notions are systematized in top-level ontologies (such as DOLCE, BFO and UFO), which have been constructed by means of a tight confrontation with the literature in linguistics, cognitive science, logic, and analytic philosophy, and provide a well-developed theory for comprehending and justifying the modeller's ontological choices. Still, even when a single top-level ontology has already been adopted, there is however a gap between top-level and core domain ontologies, since no clear methodology helps in making the basic decisions concerning the nature of the domain of discourse and the basic axiomatization choices.

In this tutorial, we develop a systematic methodology for identifying what to put in the domain of discourse, by articulating a comprehensive theory of reification and truth-making. We apply this methodology to the systematic ontological analysis of sentences containing unary predicates (properties) and n-ary predicates (relations), based on a re-visitation of the notion of individual qualities (common to DOLCE, BFO and UFO) as 'weak truthmakers', and their role in accounting for properties, relationships, and events.

MLwO: Semantic similarity and machine learning with ontologies

Organisers

Robert Hoehndorf	King Abdullah University of Science and Technology, Saudi Arabia
Maxat Kulmanov	King Abdullah University of Science and Technology, Saudi Arabia

Ontologies have long provided a core foundation in the organization of domain knowledge and are widely applied in several domains. With hundreds of ontologies currently available and large volumes of data accessible through ontologies, there are a number of new and exciting opportunities emerging in using ontologies for data analysis and predictive analysis. This tutorial will review existing methods for computational data analysis through ontologies based on semantic similarity and introduce different methods for machine learning with ontologies that were recently developed. We will introduce knowledge graph embeddings that project ontologies (as components of knowledge graphs) into vector spaces, machine learning approaches based on random walks, and model-theoretic approaches for learning with ontologies.
The tutorial will include hands-on components using Jupyter notebooks, and participants should participate with their own laptop computer.

SNOMED: SNOMED CT Tutorial

Organisers

Stefan Schulz	Medical University of Graz, Austria
Yongsheng Gao	SNOMED International, UK
Stefan Sabutsch	ELGA GmbH, Austria
Nina Sjencic	ELGA GmbH, Austria

The international standard SNOMED CT, an ontology-based clinical terminology, is increasingly used to support interoperability in health care. With about 350,000 classes and a rich set of axioms conforming to OWL-EL profile it is probably the

world's largest ontology. However, many legacy issues prevail, and collaboration with the Applied Ontology community is of great value for quality improvement and ontological well-formedness.
This tutorial of 2 x 90 min will present SNOMED CT to the typical audience of JOWO, but is also open for implementers and potential users. It encompasses SNOMED CT's architectural principles and design patterns, foundational issues like implicit and explicit upper-level assumptions, the dealing with epistemic aspects, interfacing with other ontologies, SNOMED CT and natural language, formats and use cases. The tutorial is initiated by Stefan Schulz, Medical University of Graz. He has accompanied the evolution of SNOMED CT during the past 15 years, participated in several projects around SNOMED CT and served the SNOMED organisation (SNOMED International, former IHTSDO) in working groups and advisory committees.

TLO: Top Level Ontologies (ISO/IEC 21838)

Organisers

Barry Smith	SUNY at Buffalo, USA
Michael Gruninger	University of Toronto, Canada

This tutorial will introduce ISO/IEC:21838 Top-Level Ontologies, a multi-part standard, Parts 1 and 2[22] of which are currently in the final – Draft International Standard (DIS) – stage of review. ISO/IEC:21838 has been created under the auspices of Joint Technical Committee 1 of the International Standards Organization and the International Electrotechnical Commission, which is responsible for standards in the domain of information technology. Part 1 of the standard lays down the definition of 'top-level ontology' and provides a statement of the requirements to be satisfied by any ontology claiming to be conformant to this definition. Part 2 documents Basic Formal Ontology (BFO) in light of the requirements stated in Part 1. Further parts are envisaged, including a specification of DOLCE and of the TUpper ontology (see below). The tutorial is divided into four sections.

Section 1 (Barry Smith) will describe the ISO standardization process. It will provide a detailed overview of the contents of Part 1 of ISO/IEC:21838 and of the process to be followed in assessing candidate top-level ontologies to be included as further Parts.

[22] See https://www.iso.org/standard/71954.html and https://www.iso.org/standard/74572.html.

Section 2 (Barry Smith) will provide an introduction to BFO[23] and an overview of some of the major applications of BFO in biomedicine[24], engineering[25], and defense[26].
It will provide an outline of the changes made in BFO as a result of this standardization process. These include a new Common Logic (CL) formalization of BFO (BFO-ISO-CL) together with a proof of consistency. It also includes an OWL formalization of BFO together with a proof of derivability from BFO-ISO-CL.

Section 3 (Alan Ruttenberg) will provide an account of the axiomatization and consistency proof for BFO-ISO-CL, and of the proof of derivability of BFO-ISO-OWL. He will focus on novel features of the latter, including its treatment of time-indexed relations such as continuant parthood or participation, where the relations may have different targets at different times. Because OWL has only binary relations, a direct translation of such relations is not possible. The approach used for BFO-ISO-OWL is engineered to enable access to time indexed-relations while at the same time having a clear translation to BFO-ISO-CL and thus also to BFO-ISO-FOL. There will be a discussion of benefits of this approach and remaining open problems.

Section 4 (Michael Grüninger) will present draft proposals for two further Parts of ISO/IEC:21838, representing DOLCE (the Domain Ontology for Linguistic and Cognitive Engineering), on the one hand, and the TUpper Ontology on the other. Where DOLCE, like BFO, follows a traditional top-down view of the relation between top-level and domain ontologies, TUpper follows what can be thought of as a sideways approach. This means that it provides not a single axiomatization centred on a taxonomy, but rather considers an upper ontology to be a collection of generic plug-and-play ontology modules incorporating classes relating for example to time, process, and space.

The tutorial will provide an opportunity for discussion of the issues raised by these proposals and, more generally, by the idea of a top-level ontology as defined in this standard.

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Keynotes

Antony Galton, **Theories of Time and Temporality: A Guided Tour for Ontologists**

Research in the logic, ontology, and metaphysics of time has over many years generated a bewildering variety of different theories and points of view, presenting a range of choices between, for example, A-theories vs B-theories, tensed vs tenseless logics, endurantism vs perdurantism, presentism vs eternalism, and three-dimensionalism vs four-dimensionalism. To add to all this there is the recurrent problem of how, if it is even possible at all, to reconcile "common sense" views of time with the findings of physics, in particular in relation to quantum theory and relativity. In this talk I will attempt to act as a "tour guide" through this rich and fascinating landscape, and in particular to point out the implications of different choices of theory for the practical ontologist, from both realist and conceptualist perspectives.

Yongsheng Gao, **Insights into Large-Scale Ontology Production**

SNOMED CT is the most comprehensive, multilingual clinical healthcare terminology in the world, which enables consistent representation of clinical content in electronic health records. The core component types in SNOMED CT are concepts, descriptions and relationships. These concepts and descriptions represent diagnosis, clinical findings like signs and symptoms, therapeutic, diagnostic, and administrative procedures. It also includes observables (for example, heart rate), body structures, organisms, substances, pharmaceutical products, physical objects, and many other types of information. The meaning of concepts is defined by axioms in formal description logic, whereas inferred relationships between concepts are generated from axioms by reasoners to meet a variety of primary and secondary uses.
SNOMED International is a not-for-profit organization that owns and maintains SNOMED CT. The content has been developed collaboratively to ensure that it meets the diverse needs and expectations of clinicians worldwide. We engage with the global healthcare community to improve SNOMED CT and patient safety.
In this talk, I will cover the organisation structure, SNOMED CT logic profile, concept modelling and templates, content quality assurance, release and OWL representation.

Valentina Presutti, **ArCo: the Knowledge Graph of Italian Cultural Heritage**

ArCo is a very ambitious ontology project. Starting from the official central catalogue of Italian Cultural Heritage (maintained by the Ministry) as its main source, its goal is to release an open knowledge graph encoding knowledge about the entities described in catalogue records. This means going beyond the mere

representation of their metadata. Although there's still a long way to go, ArCo reached its first 'stable' version (https://w3id.org/arco). The experience in developing this project has taught us important lessons both in knowledge engineering in general, and on its application to Cultural Heritage. In this talk I will tell ArCo's story and lessons learned focusing on methodological, social and ontological perspectives.

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