Jolita Ralyté · Sharma Chakravarthy ·
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LNCS 13607

Conceptual Modeling

41st International Conference, ER 2022
Hyderabad, India, October 17–20, 2022
Proceedings

Springer

Lecture Notes in Computer Science 13607

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ISSN 0302-9743 ISSN 1611-3349 (electronic)
Lecture Notes in Computer Science
ISBN 978-3-031-17994-5 ISBN 978-3-031-17995-2 (eBook)
https://doi.org/10.1007/978-3-031-17995-2

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

We are pleased to welcome you to the proceedings of the 41st edition of the International Conference on Conceptual Modeling (ER 2022), which took place during October 17–20, 2022. Originally, the conference was planned to take place in the beautiful city of Hyderabad, India, but due to the uncertain COVID-19 situation it was finally held virtually.

The ER conference series aims to bring together researchers and practitioners building foundations of conceptual modeling and/or applying conceptual modeling in a wide range of software engineering fields. Conceptual modeling has never been more important in this age of uncertainty. As individuals, organizations, and nations face new and unexpected challenges, software and data must be developed that can cope with and help address this new uncertainty in an ever-faster changing world. Conceptual modeling can be used to describe, understand, and cope with increasing levels of uncertainty in our world. Conference topics of interest include the theories of concepts and ontologies underlying conceptual modeling, modeling languages, methods and tools for developing and communicating conceptual models, and techniques for transforming conceptual models into effective implementations.

This year, ER 2022 chose as an overall theme "Conceptual Modeling to Support Big Data Analytics and AI". Big data analytics demands modeling complex data in a variety of models and accommodating the 5V's (Volume, Velocity, Variety, Value, and Veracity). Can the conceptual modeling community seize the opportunity to meet the needs of big data analytics? Conceptual modeling helps deep understanding of data and knowledge that is the backbone of AI systems. The modern data-driven AI systems have less representation schemes for the input data and the output. Techniques that aid the conceptual understanding of data movement through deep learning models help to develop and apply these learning models.

A total of 82 papers were submitted to the main track of the conference. Each paper went through a thorough review process and received at least three reviews from members of the Program Committee. The papers with no clear decision were discussed online. The discussions were moderated by senior Program Committee members who helped us with the final selection by providing recommendations and writing meta-reviews. We are deeply grateful to all the members of the Program Committee for their competence and fairness. The results of the review process allowed us to accept 19 high-quality full papers and 11 short papers which are included in this volume.

In addition to the paper presentations organized in eight sessions, the conference program included four inspiring keynote talks: "Conceptual Modelling in the Age of Artificial Intelligence and Quantum Computing", by Wolfgang Maaß from the Saarland University, Germany; "In an Increasingly Digital World, You Have to Put the People First", by Bas van Gils from Strategy Alliance, The Netherlands, and Antwerp Management School, Belgium; "Modeling and Software", by Pankaj Jalote from IIIT-Delhi, India; and "Threat Intelligence Modeling Using Graphs", by Ashish Kundu from

Cisco Research, USA. We thank the speakers for sharing their knowledge, research achievements, and practice insights.

Besides the main track, ER 2022 hosted a Doctoral Symposium, where PhD students could present their research projects and receive advice from advanced academics, and a Forum, Demo and Poster track, allowing researchers to present novel and innovative outcomes regarding conceptual modeling.

Finally, the conference program also included five interesting tutorials and a panel on "New Frontiers for Conceptual Modeling". We thank the presenters for transmitting their knowledge and expertise to the ER community.

Overall, organizing ER 2022 was a great pleasure, since we had an exceptional Organizing Committee. We thank all the chairs for their engagement and contribution.

We also thank Springer for their assistance in the production of the conference proceedings and EasyChair for providing an efficient conference management system. Special thanks to our sponsors and to the ER Steering Committee.

October 2022

Jolita Ralyté
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Abstracts of Invited Keynotes

Conceptual Modelling in the Age of Artificial Intelligence and Quantum Computing

Wolfgang Maass [1,2]

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Keynote Abstract

Models are not true, but some are useful. Models are either used as mental constructs by individuals or they are used by groups as social constructs. Conceptual modeling has always focused on socially constructed, explicit representations that are useful for gaining shared understanding of an affair or even for designing and implementing technical systems, most of all information systems.

For mental representations of individuals, the working hypothesis of neuroscience is that mental representations are embossed into neural structures and ultimately into electric signals. Socially constructed conceptual models require explication by representations governed by some shared conceptual-modelling grammar (Wand & Weber 2001), i.e., they become social reality by information in a medium.

Different phases of conceptual modeling have been conducted in the past decades. Initially, conceptual models were fully controlled and "closed" representations, e.g., frames. This was followed by a phase of conceptual models that are unrestricted ("open") for capturing the richness of human knowledge in general, most of all ontologies. Statistical models and machine learning models often lack direct connections to individual knowledge and socially constructed knowledge but emerge from data alone. The underlying assumption is that data is taken directly from reality and is therefore objective. Recent discussions on biases and distortions of data raise the question of the social construction of data as well. Current research on explainability and interpretability tries to build bridges between both fields. Hybrid models are an attempt in this direction by trying to merge socially constructed conceptual models with machine learning models. The success of machine learning models has initiated chip design research to develop dedicated chips that can directly support AI processing. This might have repercussions on preferred designs of information systems and machine learning models. Even more advanced are quantum computing and quantum information theory when transforming data representations into quantum representations that are accessible by quantum computing algorithms.

In this talk, common aspects between all these fields are discussed and some thoughts on research questions will be presented. A focus will be laid on the interplay between conceptual modeling and machine learning models but also some connections to advanced chip designs and quantum computing are given.

In an Increasingly Digital World, You Have to Put the People First

Bas van Gils[1,2]

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Keynote Abstract

Digital transformation is a key trend in which data plays a crucial role. As a result of the ongoing digital transformation, in line with the *law of requisite variety*, I see increased complexity and variety that helps in dealing with the challenges of today. Complexity is not bad in and of itself, as long as we have enough understanding of the organization in order to manage it effectively, and even use it to our advantage.

Three real-world cases show that organizations struggle with data/data management. Key questions in this are: (1) Do we know our data well enough in order to use it? (2) How do we balance "grip on data" with "value creation"? I will argue that effective use of models can help answer these questions. This is not a new position: several scholars have made this claim in the past as well. Very few organizations appear to have a mature modeling capability, leading to high cost, low agility, and hindering digital transformation. It is entering to ponder how this state of affairs came to be: why is modeling such an under valued skill in light of the fact that both scientific theories as well as heuristic frameworks emphasize it so strongly? Going a step further: why is "theory" such a dirty word in most organizations, up to the point where considering the use of heuristics-based frameworks is already cause for raised eyebrows and serious discussions?

There is no silver bullet that will improve the status quo: if there was, we would have found it by now. I will propose a strategy that combines a fast cycle (learning by doing) and a slow cycle (build the capability, re-learn the value of theory/models) to move forward. This generic approach can only be successful when tailored to the specific situation in an organization. Last but not least, I will argue that training and experimentation are key enablers: don't wait to educate people when they are in the field but start already during their university education.

Modeling and Software

Pankaj Jalote

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Keynote Abstract

No complex system can be built without effective modeling. And software systems are complex. Hence, modeling is necessary for building software systems, and a range of models are used for different tasks in the software development process – each playing an important role for that task. The nature and use of models in building a system, however, depends on the nature of the system also – if the system being developed is "hardware" which is costly to change, more rigorous and detailed modeling becomes necessary. If the system being developed is "software" which is easy to change and the cost of change is not high, modeling can be at higher levels of abstraction helping develop the software solution, rather than guiding the development of the details of the system. In other words, for software it is often desirable to have a gap between models and the final solution, and while models guide the development of the solution, it may be acceptable to have the final solution diverge from the model. In such situations, reverse engineering models from the solution can also be useful. Detailed modeling is more appropriate for application domains where errors and changes in the solution are much more expensive. In such cases, domain specific modeling can be useful which may lead to executable models. However, if models are to be executable, then the modeling language becomes another programming language at a higher level of abstraction and needs to compete in other programming languages for that domain.

Threat Intelligence Modeling Using Graphs

Ashish Kundu

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Keynote Abstract

Security attacks form a system of specific flow of computation and data by one or multiple threats. Attacks follow a set of steps in a sequence. Threats work together as threat groups. Holistic 360-degree defenses against APTs often interconnect multiple threat intelligence computation and defense mechanisms. Each of these processes have a graph structure inherent to their execution. Graphs can be used to model spatio-temporal dimensions and flows of different facets of security as well as privacy. In our previous work, we have studied the use of graphs for modeling security lifecycle, attacks, attack surface as well as defense modeling. Moreover, we have also modeled threat intelligence as a system of graphs and using graph analytics and graph deep learning in order to predict, infer, extract features and information for assuring holistic security. Such work has been developed in the context of autonomous cars, AI, cloud and edge computing. In this talk, we will also explore how to use NLP and NLU on how to automatically construct such graph models for specific systems under protection/attack.

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