LIPIcs – Leibniz International Proceedings in Informatics

LIPIcs is a series of high-quality conference proceedings across all fields in informatics. LIPIcs volumes are published according to the principle of Open Access, i.e., they are available online and free of charge.

Editorial Board

- Luca Aceto (Chair, Reykjavik University, IS and Gran Sasso Science Institute, IT)
- Christel Baier (TU Dresden, DE)
- Mikolaj Bojanczyk (University of Warsaw, PL)
- Roberto Di Cosmo (Inria and Université de Paris, FR)
- Faith Ellen (University of Toronto, CA)
- Javier Esparza (TU München, DE)
- Daniel Kráľ (Masaryk University - Brno, CZ)
- Meena Mahajan (Institute of Mathematical Sciences, Chennai, IN)
- Anca Muscholl (University of Bordeaux, FR)
- Chih-Hao Luke Ong (University of Oxford, GB)
- Phillip Rogaway (University of California, Davis, US)
- Eva Rotenberg (Technical University of Denmark, Lyngby, DK)
- Raimund Seidel (Universität des Saarlandes, Saarbrücken, DE and Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Wadern, DE)

ISSN 1868-8969

https://www.dagstuhl.de/lipics
Contents

Preface
Carlo Combi, Johann Eder, and Mark Reynolds ........................................ 0:vii

TIME Steering Committee ........................................................................ 0:ix

PC Members .............................................................................................. 0:xi

List of Authors .......................................................................................... 0:xiii

Invited Talks

Simple Temporal Networks: A Practical Foundation for Temporal Representation and Reasoning
Luke Hunsberger and Roberto Posenato ........................................ 1:1–1:5

Extreme-Scale Model-Based Time Series Management with ModelarDB
Torben Bach Pedersen ........................................................................ 2:1–2:2

Kernel Machines in Time
Johan Suykens ...................................................................................... 3:1–3:1

Panel Description

Temporal Big Data Analytics: New Frontiers for Big Data Analytics Research
Alfredo Cuzzocrea .................................................................................. 4:1–4:7

Regular Papers

Model Checking of Stream Processing Pipelines
Alexis Bédard and Sylvain Hallé ............................................................ 5:1–5:17

Investigation of Database Models for Evolving Graphs
Alexandros Spiitalas, Anastasios Gounaris, Kostas Tsichlas, and
Andreas Kosmatopoulos ........................................................................ 6:1–6:13

Interval Temporal Random Forests with an Application to COVID-19 Diagnosis
Federico Manzella, Giovanni Pagliarini, Guido Sciavicco, and
Ionel Eduard Stan ................................................................................ 7:1–7:18

Past Matters: Supporting LTL+Past in the BLACK Satisfiability Checker
Luca Geatti, Nicola Gigante, Angelo Montanari, and Gabriele Venturato .... 8:1–8:17

PSPACE-Completeness of the Temporal Logic of Sub-Intervals and Suffixes
Laura Bozelli, Angelo Montanari, Adriano Peron, and Pietro Sala .......... 9:1–9:19
Contents

Deciding FO-Rewritability of Ontology-Mediated Queries in Linear Temporal Logic
Vladislav Ryzhikov, Yury Savateev, and Michael Zakharyaschev .......................... 10:1–10:15

A Neuro-Symbolic Approach to Structured Event Recognition
Gianluca Apriceno, Andrea Passerini, and Luciano Serafini ............................... 11:1–11:14

Model Checking Timed Recursive CTL
Florian Bruse and Martin Lange ................................................................. 12:1–12:14

Efficient Anytime Computation and Execution of Decoupled Robustness
Envelopes for Temporal Plans
Michael Cashmore, Alessandro Cimatti, Daniele Magazzeni, Andrea Micheli, and
Parisa Zehtabi ........................................ 13:1–13:14

Achieving a Sequenced, Relational Query Language with Log-Segmented
Timestamps
Curtis E. Dyreson and M. A. Manazir Ahsan ................................................. 14:1–14:13

Olisipo: A Probabilistic Approach to the Adaptable Execution of Deterministic
Temporal Plans
Tomás Ribeiro, Oscar Lima, Michael Cashmore, Andrea Micheli, and
Rodrigo Ventura .................................................. 15:1–15:15

A One-Pass Tree-Shaped Tableau for Defeasible LTL
Anasse Chafik, Fahima Cheikh-Alili, Jean-François Condotta, and
Ivan Varzinczak ...................................................... 16:1–16:18

1 1/2-Player Stochastic StopWatch Games
Sparsa Roychowdhury ................................................................. 17:1–17:18
The 28th International Symposium on Temporal Representation and Reasoning (TIME 2021) was planned to take place in Klagenfurt, Austria, but had to move to an online conference due to the insecurities and restrictions caused by the pandemic. Since its first edition in 1994, TIME Symposium is quite unique in the panorama of the scientific conferences as its main goal is to bring together researchers from distinct research areas involving the management and representation of temporal data as well as the reasoning about temporal aspects of information. Moreover, TIME Symposium aims to bridge theoretical and applied research, as well as to serve as an interdisciplinary forum for exchange among researchers from the areas of artificial intelligence, database management, logic and verification, and beyond.

Besides the three traditional tracks on

- Time in Artificial Intelligence
- Temporal Databases
- Temporal Logic and Reasoning

this year featured two additional special tracks on

- Temporal representation and reasoning for COVID-19
- Temporal explainability: connecting symbolic and sub-symbolic temporalities

Indeed, such a strange and long period of COVID-19 pandemic pushed for strong research efforts in some previously unexplored direction, namely the temporal issues in any context having to manage Covid-19 pandemic (healthcare, medicine, social contexts, school, and so on). On the other side, the need of explaining the results coming from sub-symbolic AI approaches is becoming more and more challenging and widespread. Thus, it is important to push for research dealing with some kind of temporal logics/system/rules/visualization for interpreting/explaining the results of machine learning algorithms considering temporally relevant problems.

The 2021 TIME edition, received a total of 28 paper submissions representing a wide range of research topics in the areas of artificial intelligence, databases, and theoretical computer science, some of them explicitly focusing on the topics of the two special tracks. Submissions came from Europe, North America, Africa, and Asia. We would like to thank all the authors of the submitted papers, as they have helped to build a successful TIME 2021 symposium.

As a result of the review process coordinated by the PC chairs, 13 papers were selected for full presentation at the symposium. The range of the considered topics is very wide – without trying to mention each specific topic, they run from temporal logics to temporal plans, to data models and query languages for new kinds of temporal data.

Most papers received 3 or more reviews, and each paper received at least two detailed reviews. All papers were discussed intensively by the program committee.

Besides having such a high number of high-quality reviews, the PC members and the program chairs have been involved in a deep additional discussion on many papers, to reach a final sound decision about rejection and acceptance.

We are pleased to include invited talks by leading scholars in our scientific communities: Torben Bach Pedersen (Aalborg University, Denmark), Johan Suykens (KU Leuven, Belgium), Roberto Posenato (University of Verona, Italy) and Luke Hunsberger (Vassar College, USA).
Finally, the program is completed by a panel coordinated by Alfredo Cuzzocrea, where experts in the field will share their views and discuss research achievements and open challenges of Temporal Big Data Management.

We hope that the set of selected papers, their presentations, the invited talks, and the panel will help to stimulate and improve several research efforts in the area of temporal representation and reasoning.

The COVID-19 pandemic has created uncertainty and difficulties for people throughout the world. As we acknowledge the consequent concerns about health and safety, after having closely monitored the evolution of the pandemic, we decided to organize TIME 2021 completely on-line, as the evolution, still fast changing, unstable and different in different countries, did not allow a successful organization of an in-presence event.

We would like to thank here all the members of the Program Committee and the additional reviewers, who spent their time and volunteered their expertise to set up the final program. We want also to thank Marco Franceschetti, for his efforts in organizing a successful symposium.

Finally, we would like to acknowledge the generous support of the following institutions: Department of Informatics-Systems of the Alpen-Adria Universität Klagenfurt, Austria, and Department of Computer Science of the University of Verona, Italy. The open access publication of these proceedings was supported by the Alpen-Adria-Universität Klagenfurt, Austria.

Even though an in-presence symposium would be the ideal way of sharing ideas, discussing and strengthening possible collaborations to advance our community, we are sure that the on-line event increased the outreach to make the current and next TIME editions even more attracting and with a long-lasting research impact.

Carlo Combi, University of Verona, Italy
Johan Eder, University of Klagenfurt, Austria
Mark Reynolds, University of Western Australia, Australia

TIME 2021 Program Co-chairs
TIME Steering Committee

Alexander Artikis  
NCSR “Demokritos”  
Greece  
a.artikis@iit.demokritos.gr

Patricia Bouyer  
CNRS and ENS Paris-Saclay  
France  
bouyer@lsv.fr

Carlo Combi  
University of Verona  
Italy  
carlo.combi@univr.it

Johann Eder  
University of Klagenfurt  
Austria  
johann.eder@aau.at

Thomas Guyet  
IRISA  
France  
thomas.guyet@irisa.fr

Luke Hunsberger  
Vassar College  
United States  
hunsberger@vassar.edu

Martin Lange  
University of Kassel  
Germany  
martin.lange@uni-kassel.de

Angelo Montanari (chair)  
University of Udine  
Italy

Shankara Narayanan Krishna (Krishna S.)  
IIT Bombay  
India  
krishnas@ece.iitb.ac.in

Mark Reynolds  
University of Western Australia  
Australia  
mark.reynolds@uwa.edu.au
PC members

Alessandro Artale
Free University of Bolzano-Bozen
Italy
artale@inf.unibz.it

Nelly Bencomo
Aston University
UK
nelly@acm.org

Jürgen Bernard
University of Zurich
Switzerland
bernard@ifi.uzh.ch

Panagiotis Bouros
Johannes Gutenberg University Mainz
Germany
bouros@uni-mainz.de

Clare Dixon
University of Manchester
United Kingdom
claire.dixon@manchester.ac.uk

Curtis Dyreson
Utah State University
United States
Curtis.Dyreson@usu.edu

Marco Franceschetti
Alpen-Adria-Universitaet Klagenfurt
Austria
marco.franceschetti@aau.at

Johann Gamper
Free University of Bozen-Bolzano
Italy
gamper@inf.unibz.it

Rajeev Gore
The Australian National University
Australia
rajeev.gore@anu.edu.au

Fredrik Heintz
Linköping University
Sweden
fredrik.heintz@liu.se

Jean Christoph Jung
Universität Bremen
Germany
jeanjung@uni-bremen.de

Isak Karlsson
Stockholm University
Sweden
isak-kar@dsv.su.se

Roman Kontchakov
Birkbeck, University of London
United Kingdom
roman@dcs.bbk.ac.uk

Martin Lange
University of Kassel
Germany
martin.lange@uni-kassel.de

Peter Lucas
University of Twente
The Netherlands
peterl@cs.ru.nl

Marco Montali
Free University of Bozen-Bolzano
Italy
montali@inf.unibz.it

Emilio Muñoz-Velasco
University of Malaga
Spain
ejmunoz@uma.es

Daniel Neider
Max Planck Institute for Software Systems
Germany
neider@mpi-sws.org

Roberto Posenato
Università degli Studi di Verona
Italy
roberto.posenato@univr.it

Lucia Sacchi
University of Pavia
Italy
lucia.sacchi@unipv.it

Editors: Carlo Combi, Johann Eder, and Mark Reynolds
Leibniz International Proceedings in Informatics
Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany
PC members

Tobias Schreck
Graz University of Technology
Austria
tobias.schreck@cgv.tugraz.at

Guido Sciavicco
Universitá di Ferrara
Italy
guido.sciavicco@unife.it

Francesca Zerbato
University of St. Gallen
Switzerland
francesca.zerbato@unisg.ch
List of Authors

M. A. Manazir Ahsan (14)  
Department of Computer Science,  
Utah State University, Logan, UT, USA

Gianluca Apriceno (11)  
University of Trento, Italy;  
Fondazione Bruno Kessler, Italy

Laura Bozzelli (9)  
University of Napoli “Federico II”, Italy

Florian Bruse (12)  
School of Electrical Engineering and Computer Science, University of Kassel, Germany

Alexis Bédard (5)  
Laboratoire d’informatique formelle,  
Université du Québec à Chicoutimi,  
Saguenay, Canada

Michael Cashmore (13, 15)  
Strathclyde University, Glasgow, UK

Anasse Chafik (16)  
CRIL, University of Artois & CNRS,  
Arras, France

Fahima Cheikh-Alili (16)  
CRIL, University of Artois & CNRS,  
Arras, France

Alessandro Cimatti (13)  
Fondazione Bruno Kessler, Trento, Italy

Jean-François Condotta (16)  
CRIL, University of Artois & CNRS,  
Arras, France

Alfredo Cuzzocrea (4)  
iDEA Lab, University of Calabria, Rende, Italy;  
LORIA, Nancy, France

Curtis E. Dyreson (14)  
Department of Computer Science,  
Utah State University, Logan, UT, USA

Luca Geatti (8)  
University of Udine, Italy;  
Fondazione Bruno Kessler, Trento, Italy

Nicola Gigante (8)  
Free University of Bozen-Bolzano, Italy

Anastasios Gounaris (6)  
Aristotle University of Thessaloniki, Greece

Sylvain Hallé (5)  
Laboratoire d’informatique formelle,  
Université du Québec à Chicoutimi,  
Saguenay, Canada

Luke Hunsberger (1)  
Department of Computer Science, Vassar College, Poughkeepsie, NY, USA

Andreas Kosmatopoulos (6)  
Aristotle University of Thessaloniki, Greece

Martin Lange (12)  
School of Electrical Engineering and Computer Science, University of Kassel, Germany

Oscar Lima (15)  
DFKI German Research Center for Artificial Intelligence, Saarbrücken, Germany

Daniele Magazzeni (13)  
Kings College London, UK

Federico Manzella (7)  
Dept. of Mathematics and Computer Science, University of Ferrara, Italy

Andrea Micheli (13, 15)  
Fondazione Bruno Kessler, Trento, Italy

Angelo Montanari (8, 9)  
University of Udine, Italy

Giovanni Pagliarini (7)  
Dept. of Mathematics and Computer Science, University of Ferrara, Italy;  
Dept. of Mathematical, Physical, and Computer Sciences, University of Parma, Italy

Andrea Passerini (11)  
University of Trento, Italy

Torben Bach Pedersen (2)  
Department of Computer Science,  
Center for Data-intensive Systems,  
Aalborg University, Denmark;  
ModelarData, Copenhagen, Denmark

Adriano Peron (9)  
University of Napoli “Federico II”, Italy

Roberto Posenato (1)  
Department of Computer Science,  
University of Verona, Italy

Tomás Ribeiro (15)  
Institute for Systems and Robotics,  
Instituto Superior Tecnico, Lisbon, Portugal

Editors: Carlo Combi, Johann Eder, and Mark Reynolds  
Leibniz International Proceedings in Informatics  
Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany
Sparsa Roychowdhury (17)
Indian Institute of Technology Bombay, Mumbai, India

Vladislav Ryzhikov (10)
Department of Computer Science, Birkbeck, University of London, UK

Pietro Sala (9)
University of Verona, Italy

Yury Savateev (10)
Department of Computer Science, Birkbeck, University of London, UK;
HSE University, Moscow, Russia

Guido Sciavicco (7)
Dept. of Mathematics and Computer Science, University of Ferrara, Italy

Luciano Serafini (11)
Fondazione Bruno Kessler, Italy

Alexandros Spitalas (6)
Aristotle University of Thessaloniki, Greece

Ionel Eduard Stan (7)
Dept. of Computer Science, Birkbeck, University of Ferrara, Italy;
Dept. of Mathematical, Physical, and Computer Sciences, University of Parma, Italy

Johan Suykens (3)
ESAT-StADIUS, KU Leuven, Belgium;
Leuven.AI Institute, Heverlee, Belgium

Kostas Tsichlas (6)
University of Patras, Greece

Ivan Varzinczak (16)
CRIL, University of Artois & CNRS, Arras, France

Rodrigo Ventura (15)
Institute for Systems and Robotics, Instituto Superior Tecnico, Lisbon, Portugal

Gabriele Venturato (8)
University of Udine, Italy
KU Leuven, Belgium

Michael Zakharyaschev (10)
Department of Computer Science, Birkbeck, University of London, UK;
HSE University, Moscow, Russia

Parisa Zehtabi (13)
Kings College London, UK