# Sharing of Computable Knowledge!

# e CAADe 35 20 - 22 September 2017 Rome

#### Editors

Antonio Fioravanti, Stefano Cursi, Salma Elahmar, Silvia Gargaro Gianluigi Loffreda, Gabriele Novembri and Armando Trento Faculty of Civil and Industrial Engineering *Sapienza* University of Rome

1<sup>st</sup> Edition, September 2017

ShoCK! – Sharing of Computable Knowledge! - Proceedings of the 35<sup>th</sup> International Conference on Education and Research in Computer Aided Architectural Design in Europe, Rome, Italy, 20<sup>th</sup>-22<sup>nd</sup> September 2017, Volume 1. Edited by Antonio Fioravanti, Stefano Cursi, Salma Elahmar, Silvia Gargaro, Gianluigi Loffreda, Gabriele Novembri, Armando Trento. Brussels: Education and Research in Computer Aided Architectural Design in Europe; Rome: Dep. of Civil, Building and Environmental Engineering, Faculty of Civil and Industrial Engineering, Sapienza University of Rome.

ISBN 9789491207129 978-94-91207-12-9

Copyright © 2017

Publisher: eCAADe (Education and Research in Computer Aided Architectural Design in Europe) and Dep. of Civil, Building and Environmental Engineering, Faculty of Civil and Industrial Engineering, *Sapienza* University of Rome.

Cover Design: Ugo Maria Coraglia, Kareem Elsayed and Antonio Fioravanti. eCAADe2017 Logo Contest winners: Mohamed Elgendy and Omar Hadid (1<sup>st</sup> prize); Valerio Perna (2<sup>nd</sup> prize).

All rights reserved. Nothing from this publication may be produced, stored in computerised system or published in any form or in any manner, including electronic, mechanical, reprographic or photographic, without prior written permission from the publisher. Authors are responsible for all pictures, contents and copyright-related issues in their own paper(s).

# eCAADe 2017

# Sh<sup>o</sup>CK!

# Sharing of Computable Knowledge!

Volume 1

Proceedings of the 35<sup>th</sup> International Conference on Education and Research in Computer Aided Architectural Design in Europe

> 20<sup>th</sup>-22<sup>nd</sup> September 2017 Rome, Italy Dep. of Civil, Building and Environmental Engineering Faculty of Civil and Industrial Engineering *Sapienza* University of Rome

Edited by Antonio Fioravanti Stefano Cursi, Salma Elahmar, Silvia Gargaro, Gianluigi Loffreda, Gabriele Novembri, Armando Trento

# Patronage and Sponsors of the eCAADe 2017 Conference

Patronage



Silver sponsors



Bronze sponsors



**Technical sponsors** 



## Theme

### Sh<sup>o</sup>CK! – Sharing of Computable Knowledge!

The theme of the 35<sup>th</sup> eCAADe Conference is *Sharing of Computable Knowledge! – ShoCK!* so, we have invited eCAADe community, members of Sibling Organizations and CAADFuture friends to face this exciting theme.

Why such a strong theme? Mainly for three reasons.

The first one, is that we live in a city that has been witness of several revolutions of the conceptions of architectural space: most turning points of space perception are present here by means of architectural masterpieces as Bruno Zevi stated. I like to quote Rem Koolhaas: "It is a platitude that the presence of history in Rome is detriment to the development and display of modern art. But if that were true, Rome – *a city of successive modernities* – would never happened.".

Secondly, as my DaaD research group states "Rome is an open-air museum of architectural avant-garde masterpieces of an *uninterrupted history* where styles are juxtaposed, intertwined and *stratified* other than culturally also physically..." This concept is very close to the modern concept of cognitive sciences: to think by means of several abstraction levels of intelligence. And the third reason is that we live in a Faculty founded in 1817 – right two centuries ago - has always had a multidisciplinary approach to understand and solve problems: from the outset Architecture, Civil engineering, Bridge construction, Topography, Geometry and Mathematics subjects were present. As a matter of facts this approach it is not limited to technical aspects as – most importantly – the Faculty, now Civil and Industrial Engineering, lives in *Sapienza* University of Rome – established in 1303 – a university that pursuits the "universal" approach where each discipline enhances the others.

Going back to the theme, it involves in turn several subjects: Internet of Things, pervasive nets, Knowledge 'on tap', Big Data, Wearable devices and the 'Third wave' of AI, ... All of these disruptive technologies are upsetting our globalised world as far as it can be predicted henceforth.

So, academicians, professionals, researchers, students and innovation factories... are warmly invited to further shake up and boost our innovative and beloved CAAD world – we already are in the post-digital era – with new ideas, paradigms and points of view.

I said "CAAD world" as I think that it contains and involves several disciplines but it is a new subject it its own that overcomes the former ones.

The underlain idea of this International Conference is that as a catalyst of creative energy it pursuits with determination founders' purposes and to be a shocking vanguard, a melting

pot of novelties, in words: to become an "incubator" of innovative and seminal ideas, to generate enthusiasm, to be an occasion for new friendships and to facilitate the establishment of effective researches' networks. The title of the conference reflects well these intentions:

#### ShoCK! – Sharing of Computable Knowledge!

So the aim of the Conference was to knock our habitual design activities out, to compare the various methodological and technological trends and to disseminate the latest research advances in our community. Will our fine buildings and design traditions survive? Or, will they 'simply' be hybridized and enhanced by methods, techniques and CAAD tools? Obviously, computation is needed to match the ever-growing performance requirements, but this is not enough to answer all these questions we have to deal with the essence of problems: *improve design solutions for a better life*!

Obviously, *computation* is needed to match the ever-growing performance requirements, but this is not enough... As life is not a matter of single individuals, we need to increase collaboration and to improve *knowledge* and *sharing*. This means going back to focusing on human beings, and involves the humanistic approach, and the long history of architecture... from handicrafts to thinking to technology... to handicrafts again.

A large spiral of the *architectura* as *eternal* as our city.

#### Α.

#### Antonio Fioravanti eCAADe 2017 Conference Chair

\* This first volume of the conference proceedings of the 35<sup>th</sup> eCAADe conference contains 74 papers grouped under 13 sub-themes; both volumes contain altogether 155 accepted papers. The Conference was held at the Faculty of Civil and Industrial Engineering, *Sapienza* University of Rome, Rome, Italy, in via Eudossiana 18, Rome, on 20<sup>th</sup> – 22<sup>nd</sup> September 2017.

In addition to the accepted papers, the first volume contains *Keynote* speakers' contributions concerning the themes of their keynote lectures and the *Workshop Contributions* including the contents of workshops given; the second volume furthermore includes the *Poster Session* contents.

All the papers of these proceedings will be accessible via CuminCAD - Cumulative Index of Computer Aided Architectural Design, http://cumincad.scix.net

### Acknowledgements

Authorities, colleagues, researchers, professors, students, professionals all of you are welcomed to the 35th eCAADe conference, in Rome the *eternal city*.

It has been a long time ago – 31 years – since the previous eCAADe conference was held in this Faculty, hosted by our University - "La Sapienza".

That time, Gianfranco Carrara, one of the eCAADe founders, chaired the 4<sup>th</sup> eCAADe conference in 1986. That time on, there was only one eCAADe conference in Italy precisely in Palermo in 1995 chaired by Benedetto Colajanni and Giuseppe Pellitteri. This Faculty – now Faculty of Civil and Industrial Engineering – inspired by Parisian and Austrian academic models, is quite old as it was funded by Pope Pius VII in 1817, so now it celebrates its Bicentennial!

But it is quite young compared to our mother University "La Sapienza" that was established by the Pope Bonifacius VIII in 1303.

The original idea of bringing the eCAADe conference back to Rome goes rather back in times, I remember it was in 2009 at eCAADe conference in Istanbul. You know things take their time in Italy, so only in 2013 my Faculty approved and on 21<sup>st</sup> March 2015 eCAADe Council granted us the permission to organize the 35<sup>th</sup> conference. Over the last years several people have helped us to make this conference happen. We thank the former Dean of Civil and Industrial Engineering Faculty, Prof. Fabrizio Vestroni and especially the present Dean, Prof. Antonio D'Andrea for their supports.

During the process of organizing the eCAADe 2017 we have had the privilege to experience the supportive, collaborative and frank atmosphere of eCAADe Council, whose members, no one excluded, have helped us with all organizational aspects.

Let us be touched in remembering for his humanity the former eCAADe President, Johan Verbeke, who recently passed away. We all are sad in this moment thinking is no more physically with us now, but at the same time we are grateful to have met him and exchanged ideas on equal terms as his habit. In spirit, he is present so we can tell him: Johan, special thanks for your open-minded support, we warmly thank you! We miss you, and we do not forget you!

How cannot we mention Joachim Kieferle a friend, who is also the eCAADe President, for his encouragement and unswerving support during the last years and his ability to cut up dead-

locks into pieces? A special thanks to the great Bob Martens for his ability in organizing complex tasks and simplifying processes – Dutch origin helps – his daily support was precious and helped us relentlessly. And a "suuppper" thanks to a "super" friend as Gabriel Wurzer for his optimism and silent help in difficult issues.

Also, we wish to thank all the other previous conference organizers, Henri Achten, Rudi Stouffs and Emine Mine Thompson, for sharing their experience and knowledge. A special thanks to more recent conference organisers Bob Martens, Gabriel Wurzer, Thomas Grasl, Wolfgang E. Lorenz and Richard Schaffranek together with Aulikki Herneoja, Toni Österlund and Piia Markkanen!

Quality is the vital issue concerning conference proceedings.

To improve it we used different means: *OpenConf* conference management system that easily ensured that none of the reviewers came from the same institution as the authors; through special relationships between Liverpool University and eCAADe thank to Martin Winchester's support we were able to overcome program bugs; a second and handcraft check of interest conflicts among authors and reviewers was made during the reviewing phase; a double-blind peer review process; and an accurate reviewers' selection. The selection was fair, and only extended abstracts with high grades were admitted to full paper phase.

Quality means also typographic quality control in two ways: for printing results and for respecting author's layout; so, thanks to the well-known *ProceeDings* formatting management system eCAADe could fulfil these two needs.

Authors uploaded their extended abstracts (length of 1000 to 1500 words, two optional images, 5 to 10 references) by 1st of February 2017; each abstract was evaluated anonymously.

Altogether, we received 309 extended abstracts from 46 different authors' countries, shortly after 5 were withdrawn. Each extended abstract had three blinded peer reviews so 912 reviews were accomplished in a short time and 188 papers were accepted for full paper submission. After a while 11 of these ones were withdrawn and eventually 155 papers were published in the eCAADe 2017 Proceedings.

Let us express our very grateful appreciations for all the 132 reviewers from all over the world for their constructive and thorough comments for each author. A special thanks to reviewers who spent their time to review more than 8 extended abstracts – Joachim Kieferle and Anand Bhatt - not to mention members of "Joker Reviewers' Team": Stefano Cursi, Salma Elahmar,

Paolo Fiamma, Silvia Gargaro, Gianluigi Loffreda, Wolfgang E. Lorenz, Davide Simeone, Gabriel Wurzer and me that were able to review abstracts during the last days to accomplish missing reviews on time.

We thank and congratulate all authors for their hard work and support on using the ProceeDings tool and finalizing their full papers carefully in time. In this last phase of editing full papers we want to thank for his "extra-ordinary" work Gabriel Wurzer, the Master of the ProceeDings and Wolfgang E. Lorenz and Ugo Maria Coraglia, who with high sense of responsibility worked with us and to successfully produce high quality proceedings.

We also continued the practice started in eCAADe 2015 conference in Vienna of having all the session chairs to give prospective comments of the papers and to evoke the discourse at early stage between the author and session chair for the 27 sessions of the conference. All the session chairs also participated the peer review process of the extended abstracts.

We owe great gratitude to the session chairs for their commitment and their long-term contribution to the process until the final paper presentations.

We thank the keynote speakers and their contribution of writing the keynote papers concerning their lecture themes: Gianluca Peluffo, Chair in *Exhibition Design* and *Art & Architecture*, IULM - International University of Language and Media; John Gero, Research Prof. in *Computer Science and Architecture*, University of North Carolina at Charlotte and Krasnow Institute for Advanced Study George Mason University; and Gernot Riether, Director of *School of Architecture*, NJIT – New Jersey Institute of Technology, Editor of *DCA Journal*.

Workshops are part of eCAADe conferences, so we thank all the organizers for their workshop and for their contribution of short papers (non-peer reviewed) about the contents of their own workshop.

We are also grateful to Wolfgang Dokonal and the eCAADe Council for organizing the traditional PhD workshop for young researchers and supporting the grant winners with a subsidy for traveling to Rome.

We recovered an old tradition of previous eCAADe Conferences bringing poster session to life again, so during the conference we had 4 free lectures on interesting themes.

This year for the first time we launch an international competition linked to the Conference, the "eCAADe2017 Logo Contest" that helped in disseminate the spirit and values of eCAADe in new areas. We thank the International Jury that was made up by Antonino Saggio (President, Chair in *Information Technology applied to Architecture and Urban and Architectural design*), Eleonora Fiorani (Vice president, Chair in *Cultural Anthropology and Sociology of Innovation*),

Henri Achten (former eCAADe President, Chair in *Computer Aided Architectural Design*), Maria Argenti (Chair in *Architectural Composition* and Editor in chief of *Rassegna di Architettura e Urbanistica*), and Antonio Fioravanti (Chair in *Architectural Engineering*). Two Winners and three Honourable mentions were awarded (see on website https://www.daadgroup.org/result/). We would like to express our gratitude for the administrative help in organizing this conference to eCAADe council and especially Nele De Meyere that has provided us valuable input and lessons learned from past conferences.

We have also had support from DaaD*group* for managing the conference services, ranging from the registration process to the actual on-site registration services. A big thank you goes to PhD students Ugo Maria Coraglia and Francesco Rossini for their extra-work in critical situations.

Thanks to the sponsors we were enabled to organize an international conference as eCAADe is. Financial supports, apart Sapienza University of Rome, was generously provided by A-Sapiens, AT Advanced Technologies, Autodesk; 3TI Progetti and Bentley Systems International Ltd. Technical support was provided by Epson Italia, Gangemi Editore, Geores, it solution, Noumena and ProceeDings.

We wish to also thank Gangemi Editore in person of Giuseppe and Fabio Gangemi for their very fast and accurate printing process and the high quality of both volumes.

As a special form of sponsorship, all members of the Organizing Team and students of Architecture-Building Engineering M. Course that donated their time to help prepare and organize this conference. Thank you all !!!

Rome, 1<sup>st</sup> September 2017

Antonio Fioravanti

#### **Conference Chair**

Angelo L.C. Ciribini, Gabriele Novembri and Armando Trento

#### **Conference Vice-chairs**

# **Organizing Committee**

#### **Conference Chair**

Antonio Fioravanti

### Conference Vice Chairs

Angelo L.C. Ciribini, Gabriele Novembri, Armando Trento

#### Web

Gianluigi Loffreda, Ugo Maria Coraglia, Antonio Alfieri (IT Solution)

**Media & Communications** Ugo Maria Coraglia, Ludovica Di Martino, Isabella Calderaro

#### **Technical Support** Claudio Nardi, Marco Di Bonifaco, Francesco Furia

**Publication and Proceedings Editing** Ugo Maria Coraglia, Wolfgang Lorenz, Gabriel Wurzer, Stefano Cursi, Kareem Elsayed, Francesco Livio Rossini

#### **Reviewing Process Management** Salma Elahmar, Ludovica Di Martino

Secretary and Stationery Roberta Cannata, Anastasia Fratangelo

#### Installations and Mounting

Alireza Jahanara Francesco Livio Rossini Kareem Elsayed

#### **List of Reviewers**

- Sherif Abdelmohsen American University in Cairo, Egypt
- Henri Achten Czech Technical University in Prague, Czech Republic
- Asterios Agkathidis University of Liverpool, United Kingdom
- Hasim Altan University of Sharjah, United Arab Emirates
- Aleksander Asanowicz Bialystok University of Technology, Poland
- Gideon Aschwanden The University of Melbourne, Australia
- Phil Ayres Centre for Information Technology and Architecture (CITA), Denmark
- Guenter Barczik Erfurt School of Architecture / HMGB Architects, Germany
- Joo H Pbilip Bay Curtin University, Australia
- José Beirão University of Lisbon, Portugal
- Anand Bhatt Architexturez Imprints, India
- Henriette Bier TU Delft, Netherlands
- Nimish Biloria University of Technology Sydney (UTS), Australia
- Stefan Boeykens KU Leuven University of Leuven, Belgium
- Johannes Braumann Association for Robots in Architecture & University for Arts and Design Linz, Austria
- Peter Buš Faculty of Architecture, Czech Technical University in Prague, Czech Republic
- Gulen Cagdas Istanbul Technical University, Faculty of Architecture, Turkey
- Erik Champion Curtin University, Australia
- Teng-Wen Chang National Yunlin University of Science and Technology, Taiwan
- Sheng-Fen Chien National Cheng Kung University, Taiwan
- Benny Chow AEDAS Architects, Hong Kong
- Mark Clayton Texas A&M University, United States
- Birgul Colakoglu İstanbul Technical University, Turkey
- Stefano Cursi Sapienza University of Rome, Italy

- Bauke de Vries Eindhoven University of Technology, Netherlands
- Marcella Del signore Tulane University, United States
- Wolfgang Dokonal University of Technology Graz, Austria
- Dirk Donath Bauhaus University, Germany
- Theodoros Dounas Xian Jiaotong Liverpool University, China
- Jose Duarte Faculty of Architecture, University of Lisbon, Portugal
- Athanassios Economou Georgia Insitute of Technology, United States
- Salma El Ahmar Sapienza University of Rome, Italy
- Ahmed El Antably Arab Academy for Science, Technology and Maritime Transport, Egypt
- Sara Eloy Instituto Universitario de Lisboa, Portugal
- Halil Erhan Simon Fraser University Canada
- Alessio Erioli Alma Mater Studiorum Università di Bologna, Italy
- Paolo Fiamma University of Pisa, Italy
- Antonio Fioravanti Sapienza University of Rome, Italy
- Pia Fricker Aalto University, Finland / ETH Zurich, Switzerland
- Tomohiro Fukuda Osaka University, Japan
- Silvia Gargaro Sapienza University of Rome, Italy
- Harald Gatermann Hochschule Bochum University, Germany
- David Gerber University of Southern California, United States
- John Gero UNC Charlotte, United States
- Ipek Gursel Dino Middle East Technical University (METU), Turkey
- Jeremy Ham RMIT University, Australia
- Malgorzata Hanzl Lodz University of Technology, Poland
- Jie He School of Architecture, Tianjin University, China

- Pablo C. Herrera Universidad Peruana de Ciencias Aplicadas, Peru
- Urs Hirschberg TU Graz, Austria
- Jia Hu Independent Researcher
- Tim Ireland Kent School of Architecture, United Kingdom
- Patrick Janssen National University of Singapore, Singapore
- lestyn Jowers The Open University, United Kingdom
- Anja Jutraz University of Ljubljana, Slovenia
- Matevz Juvancic University of Ljubljana, Slovenia
- Anetta Kepczynska-Walczak Lodz University of Technology, Poland
- Sora Key Independent Researcher
- Joachim Kieferle Hochschule RheinMain, Germany
- Arto Kiviniemi University of Liverpool, United Kingdom
- Erik Kjems Aalborg University, Denmark
- Robert Klinc University of Ljubljana, Slovenia
- Michael Knight University of Liverpool, United Kingdom
- Tuba Kocaturk University of Liverpool, United Kingdom
- Volker Koch Karlsruhe Institute of Technology, Germany
- Reinhard Koenig Bauhaus-University Weimar, Germany / Austrian Institute of Technology, Austria
- Odysseas Kontovourkis University of Cyprus, Cyprus
- Jose Kos Federal University of Santa Catarina, Brazil
- Toni Kotnik Aalto University, Finland
- Sylvain Kubicki Luxembourg Institute of Science and Technology, Luxembourg
- Matthias Kulcke Hamburg University of Technology, Germany / HafenCity University Hamburg, Germany

Hyunsoo Lee - Yonsei University, Korea

Ji-Hyun Lee - Graduate School of Culture Technology (GSCT), Korea / Korea Advanced Institute of Science and Technology (KAIST), Korea

- Jos van Leeuwen The Hague University of Applied Sciences, Netherlands
- Andrew Li Kyoto Institute of Technology, Japan
- Biao Li Southeast University, China
- Katherine Liapi University of Patras, Greece
- Gianluigi Loffreda Sapienza University of Rome, Italy
- Thorsten Lomker Zayed University, United Arab Emirates
- Werner Lonsing Independent Researcher
- Wolfgang Lorenz TU Wien, Austria
- Russell Loveridge NCCR Digital Fabrication / ETH Zürich, Switzerland
- Mark Luther Deakin Uviversity, Australia
- Carlos L. Marcos Universidad de Alicante, Portugal
- Earl Mark University of Virginia, United States

Bob Martens - TU Wien, Austria

- Tom Maver Glasgow School of Art, United Kingdom
- Benachir Medjdoub Nottingham Trent University, United Kingdom
- AnnaLisa Meyboom The University of British Columbia, Canada
- Jules Moloney Deakin University, Australia
- Volker Mueller Bentley Systems, United States
- Michael Mullins Aalborg University, Denmark
- Walaiporn Nakapan Rangsit University, Thailand
- Taro Narahara New Jersey Institute of Technology, United States
- Katerina Nováková Czech Technical University in Prague, Czech Republic
- Yeonjoo Oh Hyundai Construction and Engineering, South Korea
- Konstantinos-Alketas Oungrinis Technical University of Crete, Greece
- Rivka Oxman Technion University, Israel
- Burak Pak KU Leuven, Belgium
- Hyoung-June Park University of Hawaii, United States
- Sule Tasli Pektas Bilkent University, Turkey
- Giuseppe Pellitteri Università degli Studi di Palermo, Italy
- Chengzhi Peng University of Sheffield, United Kingdom
- Frank Petzold TU Munich, Germany

Henrika Pihlajaniemi - University of Oulu, Finland Ulrich Pont - TU Wien, Austria Rabee Reffat - Assiut University, Egypt Dagmar Reinhardt - The University of Sydney, Australia Joao Rocha - University of Évora, Portugal Luís Romão - University of Lisbon, Portugal Blair Satterfield - University of British Columbia, Canada Marc Aurel Schnabel - Victoria University of Wellington, New Zealand Sven Schneider - Bauhaus-University Weimar, Germany Davide Simeone - Sapienza University of Rome, Italy Martijn Stellingwerff - TU Delft, Netherlands Rudi Stouffs - National University of Singapore, Singapore Kjeld Svidt - Aalborg University, Denmark Dina Taha - Alexandria University, Egypt Martin Tamke - The Royal Danish Academy of Fine Arts, Denmark Emine Mine Thompson - Northumbria University, United Kingdom / Independent Researcher Christian Tonn - FARO 3D Software GmbH, Germany Armando Trento - Sapienza University of Rome, Italv Bige Tuncer - Singapore University of Technology and Design, Singaore Žiga Turk - University of Ljubljana (UL-FGG), Slovenia Emrah Turkyilmaz - Istanbul Kultur University, Turkey Johan Verbeke - KULeuven, Belgium / Aarhus School of Architecture, Denmark Spela Verovsek - University of Ljubljana, Slovenia Maria Voyatzaki - Aristotle University of Thessaloniki, Greece Albert Wiltsche - TU Graz, Austria Jerzy Wojtowicz - Warsaw University of Technology, Poland

Gabriel Wurzer - TU Wien, Austria

### Contents

- 5 Theme
- 7 Acknowledgements
- 13 List of Reviewers
- 17 Dedication

#### 27 KEYNOTES

- 29 Keynote Speakers
- 31 The Digital Design Build Studio Gernot Riether
- **37 Cognitive Design Computing** John S. Gero
- 41 The navel of the world Gianluca Peluffo

#### 43 WORKSHOPS

#### **45** Internet of Homes (IoH) Eiman Elbanhawy, Daniel Gooch, Theodoros Georgiou, Aikaterini Chatzivasileiadi

#### 49 CoOptimise Kristjan Nielsen, Mariam Khademi

#### 51 Co-Design using HYVE-3D Tomás Dorta, Emmanuel Beaudry Marchand

53 Wall.4.all Bojan Tepavčević

#### 55 LightWIRE Eugenio Bettucchi, Iacopo Neri

- 57 Parametric Design of Street Profiles Rui de Klerk, José Nuno Beirão
- 59 Structuring of Teaching and Learning Situations in Architectural Education Matthias Kulcke, Wolfgang E. Lorenz, Gabriel Wurzer
- 63 Dynamo: Applications for Design and Optimization Philipp Müller, Colin McCrone

#### 65 AGENT-BASED SYSTEMS

#### 67 Extended modelling

Yannis Zavoleas, M. Hank Haeusler

- 75 Emergent order through swarm fluctuations Evangelos Pantazis, David Gerber
- 85 Modelling Buildings and their Use as Systems of Agents Davide Simeone, Stefano Cursi, Ugo Maria Coraglia
- 93 Saving Lives with Generative Design and Agent-based Modeling Sofia Sousa, Inês Caetano, António Leitão
- 103 Improving Proactive Collaborative Design Through the Integration of BIM and Agent-Based Simulations Antonio Fioravanti, Gabriele Novembri, Francesco Livio Rossini
- 109 BIM
- 111 BIM-based Multiuser Collaborative Virtual Environments for end user involvement Jesper Bendix Sørensen, Kjeld Svidt
- 119 H-BIM and web-database to deal with the loss of information due to catastrophic events

Vincenzo Donato, Stefano Giannetti, Maurizio Marco Bocconcino

- 129 Spatial Typology for BIM Takehiko Nagakura, Woongki Sung
- **137 BIM Tools Overview** Steffen Wallner, Petra von Both
- 147 The uptake of BIM Dana Matejovska, Ivana Vinsova, Michal Jirat, Henri Achten
- **153** An Automated Code Compliance system within a BIM environment Panagiotis Patlakas, Andrew Livingstone, Robert Hairstans
- 161 Theory of Games and Contracts to define the Client role in Building Information Modeling Giuseppe Martino Di Giuda, Valentina Villa, Angelo Luigi Camillo Ciribini, Lavinia

Giuseppe Martino Di Giuda, Valentina Villa, Angelo Luigi Camillo Ciribini, Lavinia Chiara Tagliabue

#### **169 BIOMIMICRY**

- **171 Biofilm-inspired Formation of Artificial Adaptive Structures** Mohammad Hassan Saleh Tabari, Saleh Kalantari, Nooshin Ahmadi
- 181 Feather-inspired social media data processing for generating developable surfaces: Prototyping an affective architecture Chenjun Liu, Tsung-Hsien Wang, Mark Meagher, Chengzhi Peng
- **191 Optimization of Facade Design for Daylighting and View-to-Outside** Mohamed Adel Wageh, Mahmoud Gadelhak
- **199 Sun Shades** Timo Carl, Markus Schein, Frank Stepper
- 209 Thermal and Daylighting Optimization of Complex 3D Faceted Façade for Office Building

Amartuvshin Narangerel, Ji-Hyun Lee, Rudi Stouffs

219 Daylight Optimization Mohammed Ayoub, Magdi Wissa

#### 229 CAAD EDUCATION - HISTORY

- 231 Reinventing Design-Build projects with the use of digital media for design and construction loanna Symeonidou
- 241 Optical Integrity of Diminished Reality Using Deep Learning Tomohiro Fukuda, Yasuyuki Kuwamuro, Nobuyoshi Yabuki
- 251 New digital trends in current architecture Giuseppe Pellitteri, Alessia Riccobono
- 261 Learning Space Augustus Wendell, Ersin Altin
- 267 Tradition and Innovation in Digital Architecture Daniel Almeida, José Pedro Sousa

#### 277 CAAD EDUCATION - PHILOSOPHY

- 279 Computation As Design Logic Indicator Anetta Kepczynska-Walczak
- **289 Competences for Digital Leadership in Architecture** Tadeja Zupancic, Johan Verbeke, Aulikki Herneoja, Henri Achten

297 Unfolding the design of architecture as a strategy to assess intellectual property Domenico D'Uva

303 Digital Design Hermeneutics Anthony Papamanolis, Katherine Liapi

313 Why Immersive? Hadas Sopher, Yehuda E. Kalay, Dafna Fisher-Gewirtzman

#### 323 CAAD EDUCATION - TEACHING

- **325 The Use of Simulation for Creating Folding Structures** Asli Agirbas
- 333 Digital Fabrication in Education Philipp Eversmann
- **343** Adaptive Lighting for Knowledge Work Environments Piia Markkanen, Henrika Pihlajaniemi, Aulikki Herneoja
- **353 Learning by Merging 3D Modeling for CAAD with the Interactive Applications** Mohamed Hassan Khalil
- **363 Teaching architecture students to code** Tim Ireland
- 373 Early design stage automation in Architecture-Engineering-Construction (AEC) projects

Ivan Renev, Leonid Chechurin, Elena Perlova

#### 383 CAAD EDUCATION - TOOLS

- **385 Contrasting Publications in Design and Scientific Research** Gabriel Wurzer, Wolfgang E. Lorenz, Tomo Cerovsek, Bob Martens
- **395 The architectural gadget factory** Volker Koch, Matthias Leschok, Petra von Both
- **401 The Role of VR as a New Game Changer in Computational Design Education** Arzu Gönenç Sorguç, Müge Kruşa Yemişcioğlu, Çağlar Fırat Özgenel, Mert Ozan Katipoğlu, Ramin Rasulzade
- **409 Computational and Modeling Tools** Firas Al-Douri, Ph.D.
- 419 Development of parametric CAAD models for the additive manufacturing of scalable architectural models Stefan Junk, Philipp Gawron

22 | eCAADe 35 - Contents

#### 427 CITY MODELLING AND GIS

**429 Parametric master planning via topological analysis using GIS data** Kuai Yu, M. Hank Haeusler, Alessandra Fabbri

#### **439 Urban Pinboard** M. Hank Haeusler, Rob Asher, Lucy Booth

- **449 Rethinking the Urban Design Process from a Data Perspective** Yuezhong Liu, Rudi Stouffs, Abel Tablada
- **461 Advanced tools and algorithms for parametric landscape urbanism** Attilio Pizzigoni, Vittorio Paris, Andrea Micheletti, Giuseppe Ruscica
- **471** Merging the Physical and Digital Layer of Public Space Chiara Farinea, Areti Markopoulou, Aldo Sollazzo, Angelos Chronis, Mathilde Marengo
- **477** Generative computational tools for the design of Urban Morphology Mateos Shehu, Anna Yunitsyna

#### 483 CITY MODELLING TOOLS

- **485 Towards a modular design strategy for urban masterplanning** Martin Dennemark, Sven Schneider, Reinhard Koenig, Abdulmalik Abdulmawla, Dirk Donath
- 495 The role of Open Data in identifying and evaluating the Livability of Urban Space

Eleanna Panagoulia

- 505 Human-driven and machine-driven decisions in urban design and architecture Jacek Markusiewicz, Adrian Kreżlik
- 515 Visual Programming meets Tangible Interfaces Gerhard Schubert, Ivan Bratoev, Frank Petzold
- 523 The city as an element of architecture Daniel Koehler
- 533 Visualizing and Analising Urban Leisure Runs by Using Sports Tracking Data Özgün Balaban, Bige Tunçer

#### 541 COLLABORATIVE AND PARTICIPATIVE DESIGN

543 On-site participation linking idea sketches and information technologies Peter Buš, Tanja Hess, Lukas Treyer, Katja Knecht, Hangxin Lu

551	<b>Learning Participatory Urban Research</b> Dieter Michielsen, Tonia Dalle, Mara Usai, Rosaura Romero, Burak Pak
561	SenCity City Monitor as a platform for user involvement, innovation and service development Henrika Pihlajaniemi, Anna Luusua, Esa-Matti Sarjanoja, Risto Vääräniemi, Eveliina Juntunen, Sini Kourunen
571	<b>DSA - Digital Support for Art</b> Armando Trento, Uwe Woessner, Joachim B. Kieferle, Andrea Cataldo
581	<b>Data-responsive Architectural Design Processes</b> Saleh Kalantari, Mona Ghandi
591	DESIGN TOOLS - PROGRAMS
593	<b>Collective Construction Modeling and Machine Learning: Potential for Architectural Design</b> Taro Narahara
601	<b>Integration of CFD in Computational Design</b> Angelos Chronis, Alexandre Dubor, Edouard Cabay, Mostapha Sadeghipour Roudsari
611	<b>Performative Materiality</b> Mercedes Peralta, Mauricio Loyola
619	Integrated Adaptive and Tangible Architecture Design Tool Qinying Li, Teng Teng
629	The Application of Daylighting Software for Case-study Design in Buildings Mark B. Luther
639	<b>APART but TOGETHER</b> Alireza Borhani, Negar Kalantar
649	DESIGN TOOLS - ROBOTICS
651	ROBOTRACK Renate Weissenböck
661	<b>Hydroassemblies</b> Dario Castellari, Alessio Erioli
671	Elements   robotic interventions II Christian J. Lange
679	<b>tOpos</b> Sebastian Bialkowski

689 Fibrous Aerial Robotics

Samuel Pietri, Alessio Erioli

699 A cloud recycling light Liss C. Werner

#### 709 DESIGN TOOLS - THEORY

#### 711 ARch4models Fábio Costa, Sara Eloy, Miguel Sales Dias, Mariana Lopes

- 719 A Visualization Dashboard and Decision Support Tool for Building Integrated Performance Optimization Mahmoud Gadelhak, Werner Lang, Frank Petzold
- 729 Integrated Algorithmic Design Renata Castelo Branco, António Leitão
- 739 Contemporary Stereotomic Trait, an Opportunity for the Development of the Volumetric Digital Architecture Irina Miodragovic Vella, Toni Kotnik
- 747 Free-form Transformation Of Spatial Bar Structures Hussein Hussein, Asterios Agkathidis, Robert Kronenburg
- 757 Evaluating the capability of EnergyPlus in simulating geometrically complex Double-Skin Facades through CFD modelling Salma El Ahmar, Antonio Fioravanti

# Improving Proactive Collaborative Design Through the Integration of BIM and Agent-Based Simulations

Antonio Fioravanti<sup>1</sup>, Gabriele Novembri<sup>2</sup>, Francesco Livio Rossini<sup>3</sup> <sup>1,2,3</sup>Department of Civil, Construction and Environmental Engineering, Sapienza University of Rome

 $\label{eq:lastice} {}^{1,2,3} \{ antonio.fioravanti | gabriele.novembri | francesco.rossini \} @uniroma1.$ 

it

Traditional design paradigms take into account phases as the process were subdivided rigidly in boxes to which pertain specific building entities, actors and LODs. In reality the process of design, a building f.i., it is not so much organized in series, nor designers deal with just a specific LOD. The process is intertwined and actors mix various type entities with different accuracy. To manage these problems, we need a new paradigm and new tools able to take immediately into account satisfied/unsatisfied constraints, to trig on consequences of choices made as far as it is possible and to link fluently and bidirectionally a 2nd layer of building abstraction (BIM) with a 3rd one of knowledge abstraction. An on-the-fly link has been established between BIM and a swarm of agent-based simulations.

**Keywords:** Agent-Based Modelling and Simulation, Behavioural Simulation, BIM, Agent-Based Building Modelling

#### **DESIGN SCENARIO**

Huge phenomena have arrived from last century: most population lives in cities from 2008 [1], energy released in the atmosphere increases temperature, pollution is more dangerous that car accidents, connections - any connection - physical and informative ones run more than capacity to understand context and information itself.

That gives huge responsibility to designers: they should understand in deep problems and boundary critical conditions, they can be able to modify event courses and Planet safety and address projects toward success or failure (Meadows 1972, Diamonds 2011). The building design process has become through the years more and more complex: indeed, it involves a huge amount of information that describes the complexity of the process and the context, in the wide means of the term. Furthermore, this complexity is evident in case of interventions on historical buildings and buildings of our current digital era are said to be more complex by information structure because of the complexity of shapes and the difficult to conduct the process in a coherent integrated way.

As other industrial sector, AEC sector presents a growing complexity, following the even higher performances required by users, the urgent need is to optimize design choices avoiding unexpected delays and cost-dangerous project variations (Dehghan et al., 2015).

Designers, in addition, need to untangle this intertwined complexity due to an increasingly extensive and detailed regulatory framework, related also with a parallel increase of requirements express by users. Finally, the designer itself is involved in a deep transformation, in favour of large design companies with hundreds of designers, belonging to specific different domain, often spread in different parts of the world (Chen and Hou, 2014) that often even work concurrently on the same entities.

In a changing world - in nature and humans needs - we need very clever tools to speed up the design, all types of design - architectural design this case, as W. Morris stated.

Managing these extreme problems means "designing". In our CAAD world, we should adhere to strategies nature did, particularly one of most successful example of adaptation: the human behaviour.

What humans do? Optimise. Optimizing thinking especially. The following study reports how a new paradigm can support architects making their choices more aware - and satisfying - in a proactive way.

#### **STATE OF THE ART**

From the outset of the Informatics Era, designers felt the need to use informatics tools to satisfy their necessities. Thus, the attempt envisioned by Nicholas Negroponte to replace the Designer (Negroponte, 1973) regarded as a "elitist middlemen" (Llach 2015) appears today differently achieved, at least partially, in practice.

Starting from the Sixties, when the digitalisation started to make its way, many tries were made toward the definition of support tools for the design activity. The experiments developed to this aim belong essentially to the set marked by two methodological opposite approaches, which have characterized CAD tools development starting from first times. These were carried out when the vision of Yona Friedman and Nicholas Negroponte were opposed to Skidmore, Owings and Merrill (SOM) approach based on Building Optimization Program (BOP) or, in other words, the "Perfect Slave" approach. (Llach 2015).

Friedman and Negroponte, in different but conceptually close studies, hypothesized a cohabitation between two intelligent species in a symbiotic relationship among them. Following the Friedman and Negroponte's perspectives, complex support systems have been developed in order to simulate the behaviour and performances achieved by building objects (and systems), allowing designers to choose design solutions to be adopted among those that match the stated requirements. That time onward, research has applied to two different challenges: to improve performance of a singular aspect of design, the "tools by tools" approach; or to have an "overall vision" of design process. Obviously, these two philosophies have had in times different outcomes, and that the edge between them has been blurred, as well as the "singular aspect", the "limited scope", is relative to a certain extent.

Another aspect to be taken into consideration since the birth of the early CAD systems, technologies and instruments is that designers act in two distinct phases: "mechanical" and "creative" ones. The former has evolved radically until to the current BIM systems, causing a radical transformation of operating methods of the design activity. The latter, in contrast, today appears practically negligible as the number and effectiveness of tools conceived. Some difficulties in giving to computer systems human-like attributes, such as curiosity and judgment, and due to the belief that fundamental design parameters escape from an objective definition hence they are hard to be represented and managed.

Nevertheless, all of these experiences are based, more or less explicitly, on the Coons paradigm (1966) were design was considered as an iterative process that alternates a creative stage" to a "mechanical stage," in which design choices are tested with respect of "performance metrics" (Llach 2015). This lack is mainly due to the undervaluation of several aspects that, instead, were central since the early experiments developed in the 70's: the flexibility, defined as the ability of a system to cope with problems of any size within a specific domain and adaptability, defined as the ability of a system to deal with problems pertaining to different domains.

The challenge to provide designers support systems with the required flexibility and adaptability became clear from the beginning. "Each designer is creating His Own library of services out of the problemoriented language. Once created, note that these operations are no less rigid than the predefined package of design commodities." (Negroponte 1973).

Some experimental systems have already shown the possibility to create advanced representations of building objects flexible and adaptable, based on the knowledge engineering, allowing the design choices verification against a system of constraints. In this way, only acceptable solutions are guaranteed. These experimental systems and, even more, the current support tools offered to designers by the market, cannot assume proactively behaviour modifications and, consequently, integrating autonomously the designer choices in order to identify solutions that can optimize the performance achieved compared with stated requirements.

# CURRENT SOLUTION FOR AN ANCIENT PROBLEM

To deal with these tasks designers and researchers extensively explored the collaborative design paradigm (Kvan 2000, Carrara et al. 2009, Achten and Beetz 2009) and turned out that to be effective it should be overcome: inconsistent data by means of BIM tools, incoherent semantic entities by means of representation of Ontologies (OWL), and the missing relationship between them by a "bridge" that links these two layers (Fioravanti and Loffreda 2015, Beetz et al.2006).

The inconsistent database management problem has been treated by J. Gray the Google Earth inventor and now it is no more a taboo to deal with inconsistent entities, f.i. different interpretations of an archaeological site entities by means of ontologies belonging to different archaeologists (Cursi et al. 2015), or putting together ontologies and shape grammars (de Klerk and Beirao 2016).

We already explored in a previous study the possibility to realize a partial "proactive" design tool (Carrara et al. 2013), but with traditional ontologies it is possible to treat only entity property incoherencies (2nd layer) not to treat fuzzy entities.

Although the current BIMs provided a multidisciplinary platform, and the possibility to develop the design phase in a concurrent way among different-located work set, the design activity request a real software environment, composed by a huge number of digital tools, often with lack of interoperability (Miettinen and Paavola 2014), forcing designers making many data-transfer operations among different forms and tools. Consequently, this intricate process results time-consuming and error-prone. Evidently, the envisioned mutual complementary improving, and role interchanges between computer and designer that, nowadays, are getting closer to the dream of human-computer co-operation.

To attain these aims, the DaaDgroup at Sapienza University of Rome, is developing some experiences aimed at overcome present days' paradigm and building design systems by an Agent-Based development environment integrated with current BIM systems system to link the 2nd layer (building abstraction - BIM) with the 3rd one (knowledge abstraction). This solution is capable to offer the required flexibility and adaptability, taking a proactive role able to complement 2nd with 3rd reasoning layer, respecting to the "first-order logic" [2] and leverage the designer activity through the identification of near optimal design solutions.

#### INTEGRATING BIM AND AGENT-BASED SIMULATIONS

To smooth the design process, we addressed to the agents' representation that can dynamically adapt solution (if any) to an ever-changing context (physical and cultural). Other two important assumptions

are: a frame representation able to change its superclass and to structuring its entities in subset; an adjacency network that takes into account not only spatial relations (rooms, loggias, etc.) but also proximity of preferred orientations or links (cultural sites, sightseeing, panoramas) or, in a closer Project Management point of view, the viability and related time and costs related to building realization at construction phase.

We have a quite powerful paradigm as the Collaborative design one that has proven to deal with these aspects, but nothing regarding intelligent classes or subclasses of entities we can group for a goal. Moreover, if we changed the orientation of a building, these tools (BIMs and ontologies) can rotate the building and just put in evidence not satisfied requirements.

The proposed system is founded on a new paradigm by means of an Agent-based Model approach (Novembri et. al. 2015) with two fundamental assumptions: modularity and flexibility ones. This system can effectively be achieved by adopting an on-demand concurrent-computing technique. The agent swarms, indeed, are highly modular as numerous the technical domains (architecture, HVAC, structures, etc.) are; and the system is so flexible as allows swarms of agents (or a single agent of them) to hotswap when they are required at the moment. These agents can be distributed (also geographically) and can operate concurrently. However, this process is normally avoided by BIM systems because a concurrent access to the instance of the model can easily generate situations where designer choices and the proposed systems actions can cause rat race condition conflicts. A rat race, however, is an endless, selfdefeating, or pointless pursuit. It brings to mind the image of lab rats racing through a maze to get the "cheese" much like the single project domains tries to get an optimal design solution but, when integrated with other domains, is useless.

These agents can be modelled by means of an old-new language (Lisp) linked to the lower ontologies layer. This way we are free to customize agents according to our needs and allow them to call libraries, different languages, external functions, ontologies and BIM programs at will. Another interesting characteristic is its nature of the interpreted language that can trig immediately consequences on related entities.

Thus, an interesting development environment called BIM Work-Bench (BWB) can match desired synchronous characteristics with BIMs limit need by means of an embedded communication mechanism. There, every project change, (f.i. updating or adding components, characteristics, spaces, etc.) made by designer into the BIM environment gets Actors (in terms of messages to be executed), that is transferred immediately to the correspondent Agents. Consequently, this 'intelligent' system uses the eventinput to elaborate action(s) to realise choices into the BIM system. This is made possible by means of modelling Actors (Hewitt 1973) that manages effectively communication among them. The system has been implemented by AKKA.net tool, that improves the actors' effectively modelling through a messagebased and asynchronous process, avoiding involving a huge quantity of computational power. Furthermore, this tool provides a hierarchic structure with the creation of a Supervisor-Actor, that can manage several data belonging to different domains. Another challenge to be dealt with is the simulation of a cluster organization of actors, like the human approach to create task-groups for complex problems.

To deal with these objectives we applied two ideas: a very large use of default values even if on jeopardized knowledge at different abstraction layers; an extensive use of adjacency in different domains, not only on i.e. climate, public infrastructure,

So these agents (Mei et al. 2015) should be coupled with Graph theory and complexity models, as like is for IoT to suggest the designer which is the proper windows to choose in respect with the several constraints that characterize a project as the suitable path for a car that takes into account traffic status in an automotive navigation system. Going back to the example of changing building orientation, in a façade modelled by Agents differently that previous situation it reacts to that event, trigs for an adaptation of former solution to a newer suitable for new context. Context in a broader sense like we explored in a previous research (Gargaro and Fioravanti 2014). That in turn trigs other agents in the agent's network as far as possible with information system has.

#### PROACTIVE DESIGN SYSTEM AS A COL-LABORATOR OF THE ARCHITECT

The system we are developing is a "design partner" able to dialogue with humans as, like humans, concurrently thinks at different abstraction layers and takes into account different partial solutions of different design phases. The usefulness of this approach is that agent-based systems have a complementary ability compared whit humans,

If they change an element all the reasoning network is activated as far as it will be possible. That means they extensively use their defaults (architectural components, plants, details, shapes, context conditions, etc.).

So, we are developing a system able to take into account heterogeneous entities of different knowledge abstraction layers (each of these ones with several levels of detail) in domains full of default entities, that in real time explores entity networks and puts in evidence consequences and side effects. That can be considered a true pro-active design system.

#### ACKNOWLEDGEMENTS

The research has been partially funded by Sapienza University of Rome grant 2016: "New building model Technologies for design / management in reusing building real estate by means of optimizing construction sites. Case studies historical and modern buildings".

#### REFERENCES

Achten, H and Beetz, J 2009 'What happened to collaborative design?', Proceedings of eCAADe 2009 - Computation: The new realm of architectural design, Istanbul, pp. 357-365

- Beetz, J, van Leeuwen, JP and de Vries, B 2006 'Towards a topological reasoning service for ifcbased building information models in a semantic web context', Joint International Conference on Computing and Decision Making in Civil and Building Engineering, Montréal (Canada)
- Carrara, G, Fioravanti, A and Nanni, U 2009, 'Knowledgebased collaborative architectural design', International Journal of Design Sciences & Technology, 16(1), pp. 1-16
- Carrara, G, Loffreda, G and Fioravanti, A 2013 'A Proactive Platform for Knowledge Management in Cross-Disciplinary Building Design', eChallenges e-2013, Dublin, pp. 1-10
- Coons, SA 1966, 'Computer graphics and innovative engineering design – super-sculptor', DATAMATION, 12(5), p. 32–34
- Cursi, S, Simeone, D and Toldo, I 2015, 'A Semantic Web Approach for Built Heritage Representation', Communications in Computer and Information Science, 527, p. 383–401
- Dehghan, R, Kamran, H and Ruwanpura, J 2015, 'Optimization of overlapping activities in the design phase of construction projects', *Automation in Construction*, 59, pp. 81-95
- Diamonds, J (eds) 2011, Collapse How societies choose to fail or survive, Penguin books, London
- Fioravanti, A and Loffreda, G 2015 'An Upper Abstraction Layer for', e-Challenges e-2015 - Information and Communication Technologies and The Knowledge Economy, Dublin, pp. 1-9
- Hewitt, C, Bishop, A and Steiger, R 1973 'A Universal Modular Actor Formalism for Artificial Intelligence', Proceedings of the 3rd International Joint Conference on Artificial intelligence - IJCAI, Stanford (USA), pp. 235-245
- Hung-Ming, C and Chuan-Chien, H 2014, 'Asynchronous online collaboration in BIM generation using hybrid client-server and P2P network', Automation in Construction, 45, pp. 72-85
- de Klerk, R and Beirao, J 2016 'Ontologies and Shape Grammars. A Relational Overview Towards Semantic Design Systems', *Proceedings of eCAADe 2016 -Complexity & Simplicity (vol. 2)*, Oulu (Finland), pp. pp. 305-314
- Kvan, T 2000, 'Collaborative design, what is it?', Automation in Construction, 9, pp. 409-415
- Llach, DC (eds) 2015, Builders of the Vision: Software and the Imagination of Design, Routledge

- Meadows, DH, Meadows, DL, Randers, J and Behrens, WW (eds) 1972, *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind*, Potomac Book, Rome
- Mei, S, Zarrabi, N, Lees, M and Sloot, PMA 2015, 'Complex agent networks: An emerging approach for modelling complex systems', *Applied Soft Computing*, 37(12), p. 311–321
- Miettinen, R and Paavola, S 2014, 'Beyond the BIM utopia: Approaches to the development and implementation of building information modeling', *Automation in Construction*, 43, pp. 84-91
- Negroponte, N (eds) 1973, *The Architecture Machine: Toward a More Human Environment*, The MIT Press, Cambridge, Mass. (USA)
- Novembri, G, Rossini, FL, Fioravanti, A and Insola, C 2015 'BIM and Multi-Agent Distributed Constraint Optimization', Proceeding of Back to 4.0 - Rethinking the digital construction industry, pp. 248-258
- [1] http://esa.un.org/unpd/wup/unup/p2k0data.asp
- [2] https://plato.stanford.edu/archives/win2013/ent ries/logic-classical/

# **Index of Authors**

Α		Maurizio Marco	1-119
Abdulmawla, Abdulmalik	1-485	Booth, Lucy	1-439
Abramovic, Vasilija	2-87	Borhani, Alireza	1-639
Achten, Henri	1-147, 1-289, 2-87	von Both, Petra	1-137, 1-395
Ag-ukrikul, Chotima	2-553	Botto Poaola, Matteo	2-77
Agirbas, Asli	1-325	Bouhai, Nasreddine	2-49
Agkathidis, Asterios	1-747	Brandão, Filipe	2-417
Agrawal, Varun	2-151	Bratoev, Ivan	1-515
Agustí-Juan, Isolda	2-185	Bravo, Maite	2-211
Ahmadi, Nooshin	1-171	Budak, Igor	2-389
Al-Douri, Ph.D., Firas	1-409	Buratti, Giorgio	2-259
Al-Qattan, Emad	2-363	Buš, Peter	1-543
Al-Sudani, Amer	2-673		
Alankus, Gazihan	2-31	С	
Alfaiate, Pedro	2-511	Cabay, Edouard	1-601
Almeida, Daniel	1-267	Caetano, Inês	1-93
Altin, Ersin	1-261	Calvano, Michele	2-355
Asanowicz, Aleksander	2-379	Capone, Mara	2-219
Asher, Rob	1-439	Carl, Timo	1-199
Ashrafi, Negar	2-471	Casale, Andrea	2-355
Aslankan, Ali	2-31	Castellari, Dario	1-661
Astolfi, Arianna	2-77	Castelo Branco, Renata	1-729
Ayoub, Mohammed	1-219	Cataldo, Andrea	1-571
Ayres, Phil	2-561	Cerovsek, Tomo	1-385
		Chaltiel, Stephanie	2-211
В		Chatzivasileiadi,	
Bajsanski, Ivana	2-135	Aikaterini	1-45
Balaban, Özgün	1-533	Chechurin, Leonid	1-373
Baldissara, Matteo	2-571	Chronis, Angelos	1-471, 1-601, 2-211
Bar-Yam, Yaneer	2-561	Ciribini,	
Bard, Delphine	2-603	Angelo Luigi Camillo	1-161
Baseta, Efilena	2-317, 2-611	Civetti, Laura	2-317
Beaudry Marchand,		Çolakoğlu, Birgül	2-309
Emmanuel	1-51, 2-729	Collins, Jeffrey	2-657
Beirão, José Nuno	1-57, 2-581, 2-619	Coraglia, Ugo Maria	1-85, 2-519, 2-649
Bettucchi, Eugenio	1-55	Costa, Fábio	1-711
Bialkowski, Sebastian	1-679	Currà, Edoardo	2-39
Bieg, Kory	2-399	Cursi, Stefano	1-85, 2-519, 2-649
Bocconcino,			

D		Florián, Miloš	2-159
D'Alessandro, Daniela	2-519	Fukuda, Tomohiro	1-241, 2-495
D'Amico, Alessandro	2-39	Furuta, Airi	2-693
D'Uva, Domenico	1-297		
Dalle, Tonia	1-551	G	
Daniotti, Bruno	2-67	Gadelhak, Mahmoud	1-191, 1-719
Das, Subhajit	2-277	Galanter, Philip	2-363
Date, Kartikeya	2-503	Garai, Massimo	2-593
De Azambuja Varela,		Garcia-Amorós, Jaume	2-317
Pedro	2-193	Gawron, Philipp	1-419
De Luca, Francesco	2-431	Gentry, Russell	2-657
Decker, Martina	2-739	Georgiou, Theodoros	1-45
Del Signore, Marcella	2-537	Gerber, David	1-75
Dennemark, Martin	1-485	Gero, John S.	1-37
Di Giuda,		Ghandi, Mona	1-581
Giuseppe Martino	1-161	Giannetti, Stefano	1-119
Dickey, Rachel	2-667	Globa, Anastasia	2-711
Donath, Dirk	1-485	Glynn, Ruairi	2-87
Donato, Vincenzo	1-119	Gönenç Sorguç, Arzu	1-401
Dorta, Tomás	1-51, 2-729	Gooch, Daniel	1-45
Duarte, José Pinto	2-471, 2-477, 2-485	Griz, Cristiana	2-463
Dubor, Alexandre	1-601	Gül, Leman Figen	2-703
E		н	
El Ahmar, Salma	1-757	Habert, Guillaume	2-185
Elbanhawy, Eiman	1-45	Haeusler, M. Hank	1-67, 1-429, 1-439
Eloy, Sara	1-711	Hairstans, Robert	1-153
Elsayed, Kareem	2-167	Ham, Jeremy	2-629
Emo, Beatrix	2-637	Han, Xueying	2-729
Erioli, Alessio	1-661, 1-689, 2-593	Hassan Khalil, Mohamed	1-353
Eversmann, Philipp	1-333	Hauck, Anthony	2-277
Ezzat, Mohammed	2-241	Havelka, Jan	2-159
		Heinrich, Mary Katherine	2-561
F		Herneoja, Aulikki	1-289, 1-343
Fabbri, Alessandra	1-429	Hess, Tanja	1-543
Farinea, Chiara	1-471	Hitchings, Katie	2-347
Fernando, Shayani	2-177	Hoelscher, Christoph	2-637
Figliola, Angelo	2-115	Hollberg, Alexander	2-185
Fioravanti, Antonio	<u>1-103</u> , 1-757, 2-167,	Hou, Dan	2-443
	2-231, 2-519	Hussein, Hussein	1-747, 2-673
Fisher-Gewirtzman, Dafna	1-313		

1		Kulcke, Matthias	1-59
Inoue, Kazuya	2-495	Kuwamuro, Yasuyuki	1-241
Ireland, Tim	1-363	Kwieciński, Krystian	2-745
		Kırdar, Gülce	2-309
J			
Jahanara, Alireza	2-231	L	
Jenner, Ross	2-711	Lang, Werner	1-719
Jimenez Garcia, Manuel	2-143	Lange, Christian J.	1-671
Jirat, Michal	1-147	Lanham, Thomas	2-327
Jovanovic, Marko	2-135	Lanzara, Emanuela	2-219
Junk, Stefan	1-419	Lee, Ji-Hyun	1-209
Juntunen, Eveliina	1-561	Leitão, António	1-93, 1-729, 2-511
		Leschok, Matthias	1-395
К		Li, Qinying	1-619
Kalantar, Negar	1-639	Liapi, Katherine	1-303, 2-371
Kalantari, Saleh	1-171, 1-581	Lima, Elton C.	2-463
Kalay, Yehuda E.	1-313, 2-503	Liu, Chenjun	1-181
Katipoğlu, Mert Ozan	1-401	Liu, Yuezhong	1-449
Kepczynska-Walczak,		Livingstone, Andrew	1-153
Anetta	1-279	Lo Turco, Massimiliano	2-77
Khademi, Mariam	1-49	Lopes, Mariana	1-711
Kieferle, Joachim B.	1-571, 2-629	Lorenz, Wolfgang E.	1-59, 1-385
Kiviniemi, Arto	2-407	Loyola, Mauricio	1-611
de Klerk, Rui	1-57, 2-619	Lu, Hangxin	1-543
Knapen, Elke	2-289	Luhan, Gregory	2-327
Knecht, Katja	1-543	Lupica Spagnolo, Sonia	2-67
Kocaturk, Tuba	2-407	Luther, Mark B.	1-629
Koch, Volker	1-395	Luusua, Anna	1-561
Koehler, Daniel	1-523		
Koenig, Reinhard	1-485	Μ	
Koltsova Jenne,		Magnusson, Frans	2-683
Anastasia	2-581	Marcos, Carlos L.	2-219
Kontovourkis, Odysseas	2-125	Marengo, Mathilde	1-471
Korolija-Crkvenjakov,		Marijnissen,	
Daniela	2-389	Marjolein P.A.M.	2-299
Kotnik, Toni	1-739, 2-251	Markkanen, Piia	1-343
Kourunen, Sini	1-561	Markopoulou, Areti	1-471
Kronenburg, Robert	1-747	Markusiewicz, Jacek	1-505, 2-425, 2-745
Kruşa Yemişcioğlu,		Martens, Bob	1-385
Müge	1-401	Matejovska, Dana	1-147
Krężlik, Adrian	1-505	McCrone, Colin	1-63

McPherson, Peter	2-347	Paio, Alexandra	2-355, 2-417
Meagher, Mark	1-181	Pak, Burak	1-551, 2-553
Meex, Elke	2-289	Panagoulia, Eleanna	1-495
Mekawy, Mohammed	2-107	Pankiewicz, Mateusz	2-25
Mendes, Leticia T.	2-463	Pantazis, Evangelos	1-75
Micheletti, Andrea	1-461	Papamanolis, Anthony	1-303
Michielsen, Dieter	1-551	Papantoniou, Andreana	2-371
Miodragovic Vella, Irina	1-739, 2-251	Parigi, Dario	2-603
Mirarchi, Claudio	2-67	Paris, Vittorio	1-461
Mitov, Dejan	2-135	Pasini, Daniela	2-67
Modesitt, Adam	2-55	Pasternak, Agata	2-745
Molin, Erik	2-603	Patel, Yusef	2-347
Molloy, lan	2-277	Patlakas, Panagiotis	1-153
Moloney, Jules	2-711	Pavan, Alberto	2-67
Motalebi, Nasim	2-485	Pellitteri, Giuseppe	1-251
Müller, Philipp	1-63	Peluffo, Gianluca	1-41
Mura, Gokhan	2-31	Peng, Chengzhi	1-181
		Peralta, Mercedes	1-611
Ν		Perlova, Elena	1-373
Nagakura, Takehiko	1-129	Perna, Valerio	2-571
Narahara, Taro	1-593	Petrš, Jan	2-159
Narangerel, Amartuvshin	1-209	Petzold, Frank	1-515, 1-719, 2-107
Neri, lacopo	1-55	Pietri, Samuel	1-689
Nerla, Maria Giuditta	2-593	Pihlajaniemi, Henrika	1-343, 1-561
Nielsen, Kristjan	1-49	Pizzigoni, Attilio	1-461
Nousias, Chrysostomos	2-371	Poustinchi, Ebrahim	2-327
Novák, Jan	2-159		
Novembri, Gabriele	1-103	Q	
		Qabshoqa, Mohammad	2-407
0		Quartara, Andrea	2-115
Obradovic, Ratko	2-389		
Odom, Clay	2-97	R	
Oliveira, Sancho	2-355	Rahmani Asl, Mohammad	2-277
Ondejcik, Vladimir	2-683	Rasulzade, Ramin	1-401
Osorio, Filipa	2-355	Reinhardt, Dagmar	2-177
Ostrowska-Wawryniuk,		Renev, Ivan	1-373
Karolina	2-425	Retsin, Gilles	2-143
Özgenel,		Riccobono, Alessia	1-251
Çağlar Fırat	1-401	Riether, Gernot	1-31
		Romero, Rosaura	1-551
Р		Rossi, Andrea	2-201

Rossi, Michela	2-259	Symeonidou, Ioanna	1-231
Rossini, Francesco Livio	1-103	Słyk, Jan	2-425
Roudsari,			
Mostapha Sadeghipour	1-601	т	
Runberger, Jonas	2-683	Tablada, Abel	1-449
Ruscica, Giuseppe	1-461	Tagliabue,	
		Lavinia Chiara	1-161
S		Takizawa, Atsushi	2-693
Saggio, Antonino	2-571	Teng, Teng	1-619
Saleh Tabari,		Tepavčević, Bojan	1-53, 2-135
Mohammad Hassan	1-171	Tessmann, Oliver	2-201
Sales Dias, Miguel	1-711	Tonn, Christian	2-721
Santosi, Zeljko	2-389	Trento, Armando	1-571, 2-611
Sarjanoja, Esa-Matti	1-561	Treyer, Lukas	1-543, 2-637
Schaumann, Davide	2-503	Tsai, Barry	2-277
Schein, Markus	1-199	Tunçer, Bige	1-533, 2-545, 2-581
Schmitt, Gerhard	2-581, 2-637	Twose, Simon	2-711
Schneider, Sven	1-485		
Schubert, Gerhard	1-515	U	
Schwartz, Mathew	2-269	Usai, Mara	1-551
Shaifa, Irvin	2-327		
Sharif, Shani	2-151	V	
Sharples, Steve	2-673	Vääräniemi, Risto	1-561
Shehu, Mateos	1-477	Valenti, Graziano	2-355
Shtrepi, Louena	2-77	Varinlioglu, Guzden	2-31
Simeone, Davide	1-85, 2-519, 2-649	Velasco, Dolores	2-317
Soler, Vicente	2-143	Verbeeck, Griet	2-289
Sollazzo, Aldo	1-471, 2-317, 2-611	Verbeke, Johan	1-289
Sopher, Hadas	1-313	Verniz, Debora	2-477
Sørensen, Jesper Bendix	1-111	Vesna, Stojakovic	2-389
Sousa, José Pedro	1-267, 2-193	Vieira, Aline	2-463
Sousa, Sofia	1-93	Villa, Valentina	1-161
Squasi, Francesco	2-167	Vinsova, Ivana	1-147
Stancato, Gabriele	2-571	Vucic, Marko	2-135
Steinø, Nicolai	2-453		
Stepper, Frank	1-199	W	
Stojakovic, Vesna	2-135	Wageh, Mohamed Adel	1-191
Stouffs, Rudi	1-209, 1-449, 2-443	Wallner, Steffen	1-137
Sung, Woongki	1-129	Wang, Rui	2-711
Svidt, Kjeld	1-111, 2-603	Wang, Tsung-Hsien	1-181
Sweet, Larry	2-151	Weir, Simon	2-177

Weissenböck, Renate	1-651
Wendell, Augustus	1-261, 2-55
Werner, Liss C.	1-699
Whitelaw, Christopher	2-417
Wissa, Magdi	1-219
Woessner, Uwe	1-571, 2-629
Wurzer, Gabriel	1-59, 1-385, 2-519

#### Y

Yabuki, Nobuyoshi	1-241, 2-495
Yan, Wei	2-363, 2-527
You, Linlin	2-545
Yu, Kuai	1-429
Yunitsyna, Anna	1-477

#### Ζ

Zarzycki, Andrzej	2-269, 2-337
Zavoleas, Yannis	1-67
Zboinska, Malgorzata A.	2-683
van der Zee, Aant	2-299
Zich, Ursula	2-77
Zreik, Khaldoun	2-49
Zupancic, Tadeja	1-289





Aided Architectural Design: Internet of Things, pervasive nets, Knowledge 'on tap', Big Data, Wearable devices and the "Third wave' of AI... These disruptive technologies are upsetting a globalised world as far as it can be predicted henceforth. So, academicians, professionals, researchers, students, innovation factories,

*were* warmly invited to further shake up and boost our innovation factories, ... *were* warmly invited to further shake up and boost our innovative and beloved CAAD world. Obviously, computation is needed to match the ever-growing performance requirements but, at the same time, we have to deal with the essence of the problems: improve design solutions for a better life!

The proceedings took into account the most advanced research in Computer

As life is not a matter of single individuals, we need to increase collaboration and to improve knowledge sharing. This means going back to focusing on human beings, and it involves the humanistic approach, and the long history of architecture ... from handicrafts to thinking to technology... to handicrafts. A large spiral of the *architectura* as *eternal* as our city.

eCAADe 2017 has been hosted by the Department of Civil, Building and Environmental Engineering supported by DaaDgroup at the Faculty of Civil and Industrial Engineering founded in 1817, just two hundred years ago.

eCAADe - Education and Research in Computer Aided Architectural Design in Europe - is a non-profit making association of institutions and individuals with a common interest in promoting good practice and sharing information in relation to the use of computers in research and education in architecture and related professions. eCAADe was founded in 1983.

Editors: Stefano Cursi Salma Elahmar Silvia Gargaro

Antonio Fioravanti Gianluigi Loffreda Gabriele Novembri Armando Trento





SAPIENZA UNJVERSITA DI ROMA - EST. 1303 -

**ISBN** 9789491207136 **ISBN** 978-94-91207-13-6 GANGEMI EDITOR£