

# Ken Arroyo Otori

## Curriculum vitae

Delft University of Technology  
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### Research interests

The main focus of my research is higher-dimensional (4D and higher) data models, data structures and algorithms for Geographic Information Systems, using these dimensions to model not only space, but also other characteristics such as time and scale. However, I also work on other topics that combine geometric or topological computing with spatial information, such as geometric modelling and processing, the validation and repair of geographic data, and visualising spatial data. I like theoretical work, but what I enjoy most is implementing my ideas into working prototypes and, when they are serious enough, into free software.

### Work

- 2016–now **Postdoc researcher**, Delft University of Technology, the Netherlands.  
2011–2015 **PhD researcher**, Delft University of Technology, the Netherlands.

### Education

- 2011–2016 **PhD**, Delft University of Technology, the Netherlands.  
Title: *Higher-dimensional modelling of geographic information*  
2008–2010 **MSc in Geomatics**, Delft University of Technology, the Netherlands.  
Graduated with distinction  
Thesis: *Validation and automatic repair of planar partitions using a constrained triangulation*  
2003–2007 **BSc in Computer Science and Technology**, Monterrey Institute of Technology and Higher Education, Mexico City Campus, Mexico.  
Minor in Software Engineering

### Peer-reviewed publications

**Note:** PDFs are available at <https://3d.bk.tudelft.nl/ken/en/papers/>

- 2018 **A framework for the representation of two versions of a 3D model in 4D space.** Stelios Vitalis, Ken Arroyo Otori and Jantien Stoter. In Ken Arroyo Otori, Anna Labetski, Giorgio Agugiaro, Mila Koeva and Jantien Stoter (eds.), *13th 3D GeoInfo Conference*, ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences IV-4(W6), ISPRS, Delft, The Netherlands, October 2018, pp. 81–88.
- Modeling cities and landscapes in 3D with CityGML.** Ken Arroyo Otori, Filip Biljecki, Kavisha Kumar, Hugo Ledoux and Jantien Stoter. In André Borrmann, Markus König, Christian Koch and Jakob Beetz (eds.), *Building Information Modeling: Technology Foundations and Industry Practice*, Springer, September 2018, pp. 199–215.
- Processing BIM and GIS models in practice: experiences and recommendations from a GeoBIM project in the Netherlands.** Ken Arroyo Otori, Abdoulaye Diakité, Thomas Krijnen, Hugo Ledoux and Jantien Stoter. *ISPRS International Journal of Geo-Information* 7(8), August 2018.
- Topological reconstruction of 3D city models with preservation of semantics.** Stelios Vitalis, Ken Arroyo Otori and Jantien Stoter. In A. Mansourian, P. Pilesjö, L. Harrie and R. von Lammeren (eds.), *Geospatial Technologies for All: short papers, posters and poster abstracts of the 21th AGILE Conference on Geographic Information Science*. Lund University 12–15 June 2018, Lund, Sweden, June 2018.
- Essential means for urban computing: specification of web-based computing platforms for urban planning, a hitchhiker's guide.** Pirouz Nourian, Carlos Martinez-Ortiz and Ken Arroyo Otori. *Urban Planning* 3(1), March 2018, pp. 47–57.

- 2017 **Towards an integration of GIS and BIM data: what are the geometric and topological issues?** Ken Arroyo Otori, Filip Biljecki, Abdoulaye Diakité, Thomas Krijnen, Hugo Ledoux and Jantien Stoter. In M. Kalantari and A. Rajabifard (eds.), *12th 3D Geoinfo Conference*, ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences IV-4/W5, ISPRS, Melbourne, Australia, October 2017, pp. 1–8.
- Visualising higher-dimensional space-time and space-scale objects as projections to R3.** Ken Arroyo Otori, Hugo Ledoux and Jantien Stoter. *PeerJ Computer Science* 3:e123, July 2017.
- Modelling and manipulating spacetime objects in a true 4D model.** Ken Arroyo Otori, Hugo Ledoux and Jantien Stoter. *Journal of Spatial Information Science* 14, June 2017, pp. 61–93.
- Solving the horizontal conflation problem with a constrained Delaunay triangulation.** Hugo Ledoux and Ken Arroyo Otori. *Journal of Geographical Systems*, 19(1), January 2017, pp. 21–42.
- 2016 **Defining simple nD operations based on prismatic nD objects.** Ken Arroyo Otori, Hugo Ledoux and Jantien Stoter. In E. Dimopoulou and P. van Oosterom (eds.), *11th 3D Geoinfo Conference*, ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences IV-2/W1, ISPRS, Athens, Greece, October 2016, pp. 155–162.
- Population estimation using a 3D city model: a multi-scale country-wide study in the Netherlands.** Filip Biljecki, Ken Arroyo Otori, Hugo Ledoux, Ravi Peters and Jantien Stoter. *PLOS ONE* 11(6), June 2016.
- Voxelization algorithms for geospatial applications.** Pirouz Nourian, Romulo Gonçalves, Sisi Zlatanova, Ken Arroyo Otori and Anh Vu Vo. *MethodsX* 3, January 2016.
- 2015 **Automatically enhancing CityGML LOD2 models with a corresponding indoor geometry.** Roeland Boeters, Ken Arroyo Otori, Filip Biljecki and Sisi Zlatanova. *International Journal of Geographical Information Science* 29(12), December 2015, pp. 2248–2268.
- Automatic semantic-preserving conversion between OBJ and CityGML.** Filip Biljecki and Ken Arroyo Otori. In F. Biljecki and V. Tourre (eds.), *Eurographics Workshop on Urban Data Modelling and Visualisation*, Eurographics Association, Delft, The Netherlands, November 2015, pp. 25–30.
- Storing a 3D city model, its levels of detail and the correspondences between objects as a 4D combinatorial map.** Ken Arroyo Otori, Hugo Ledoux and Jantien Stoter. In Alias Abdul Rahman, Umit Isikdag and Francesc Antón Castro (eds.), *Joint International Geoinformation Conference 2015*, 28–30 October 2015, Kuala Lumpur, Malaysia, ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences II-2/W2, ISPRS, Kuala Lumpur, Malaysia, October 2015, pp. 1–8.
- Modelling a 3D city model and its levels of detail as a true 4D model.** Ken Arroyo Otori, Hugo Ledoux, Filip Biljecki and Jantien Stoter. *ISPRS International Journal of Geo-Information*, 4(3), September 2015, pp. 1055–1075.
- A dimension-independent extrusion algorithm using generalised maps.** Ken Arroyo Otori, Hugo Ledoux and Jantien Stoter. *International Journal of Geographical Information Science* 29(7), July 2015, pp. 1166–1186.
- An evaluation and classification of nD topological data structures for the representation of objects in a higher-dimensional GIS.** Ken Arroyo Otori, Hugo Ledoux and Jantien Stoter. *International Journal of Geographical Information Science* 29(5), May 2015, pp. 825–849.
- 2014 **A triangulation-based approach to automatically repair GIS polygons.** Hugo Ledoux, Ken Arroyo Otori and Martijn Meijers. *Computers & Geosciences* 66, May 2014, pp. 121–131.
- Constructing an n-dimensional cell complex from a soup of (n-1)-dimensional faces.** Ken Arroyo Otori, Guillaume Damiand and Hugo Ledoux. In Prosenjit Gupta and Christos Zaroliagis (eds.), *Applied Algorithms. First International Conference, ICAA 2014, Kolkata, India, January 13–15, 2014. Proceedings*, Lecture Notes in Computer Science 8321, Springer International Publishing Switzerland, Kolkata, India, January 2014, pp. 37–48.
- 2013 **Using extrusion to generate higher-dimensional GIS datasets.** Ken Arroyo Otori and Hugo Ledoux. In Craig Knoblock, Peer Kröger, John Krumm, Markus Schneider and Peter Widmayer (eds.), *SIGSPATIAL'13: Proceedings of the 21st ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems*, ACM, Orlando, Florida, United States, November 2013, pp. 398–401.
- Modelling higher dimensional data for GIS using generalised maps.** Ken Arroyo Otori, Hugo Ledoux and Jantien Stoter. In B. Murgante, S. Misra, M. Carlini, C. Torre, H. Q. Nguyen, D. Taniar, B. Apduhan and O. Gervasi (eds.), *Computational Science and Its Applications — ICCSA 2013. 13th International Conference, Ho Chi Minh City, Vietnam, June 24–27, 2013, Proceedings, Part I*, Lecture Notes in Computer Science 7971, Springer Berlin Heidelberg, June 2013, pp. 526–539.

- Representing the dual of objects in a four-dimensional GIS.** Ken Arroyo Ohori, Pawel Boguslawski and Hugo Ledoux. In A. Abdul Rahman, P. Boguslawski, C. Gold and M. N. Said (eds.), *Developments in Multidimensional Spatial Data Models*, Lecture Notes in Geoinformation and Cartography, Springer Berlin Heidelberg, Johor Bahru, Malaysia, May 2013, pp. 17–31.
- Manipulating higher dimensional spatial information.** Ken Arroyo Ohori, Filip Biljecki, Jantien Stoter and Hugo Ledoux. In Danny Vandenbroucke, Bénédicte Bucher and Joep Crompvoets (eds.), *Geographic Information Science at the Heart of Europe. Proceedings of the 16th AGILE International Conference on Geographic Information Science*, Leuven, Belgium, May 2013.
- 2012 **Validation and automatic repair of planar partitions using a constrained triangulation.** Ken Arroyo Ohori, Hugo Ledoux and Martijn Meijers. *Photogrammetrie, Fernerkundung, Geoinformation* 5, October 2012, pp. 613–630.
- Automatically repairing polygons and planar partitions with *pprepair* and *pprepair*.** Ken Arroyo Ohori, Hugo Ledoux and Martijn Meijers. *Proceedings of the 4th Open Source GIS UK Conference*, Nottingham, United Kingdom, September 2012.
- Integrating scale and space in 3D city models.** Jantien Stoter, Hugo Ledoux, Martijn Meijers and Ken Arroyo Ohori. In Jacynthe Pouliot, Sylvie Daniel, Frédéric Hubert and Alborz Zamyadi (eds.), *Proceedings of the 7th International 3D GeoInfo Conference, International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences XXXVIII–4/C26*, ISPRS, Québec City, Canada, May 2012, pp. 7–10.
- Automatically repairing invalid polygons with a constrained triangulation.** Hugo Ledoux, Ken Arroyo Ohori and Martijn Meijers. In Jérôme Gensel, Didier Josselin and Danny Vandenbroucke (eds.), *Multidisciplinary Research on Geographical Information in Europe and Beyond. Proceedings of the 15th AGILE International Conference on Geographic Information Science*, Avignon, France, April 2012, pp. 13–18.
- 2011 **Edge-matching polygons with a constrained triangulation.** Hugo Ledoux and Ken Arroyo Ohori. *Proceedings of GIS Ostrava 2011*, Ostrava, Czech Republic, January 2011, pp. 377–390.

## Supervised thesis

- 2013 **Automatic enhancement of CityGML LoD2 models with interiors and its usability for net internal area determination.** Roeland Boeters. Master's thesis, Delft University of Technology, June 2013.

## Full courses given

- 2018 **GEO1015 Digital Terrain Modelling** (2018–2019 Q2)
- 2014 **GEO1002 Geographical Information Systems and Cartography** (2014–2015 Q1)
- 2013 **GEO1002 Geographical Information Systems and Cartography** (2013–2014 Q1)

## Open source software

- 2016–now **azul**, a CityGML viewer for macOS.
- 2015–now **imbiber**, create nicely formatted HTML from BibTeX files directly from Jekyll.
- 2014–2016 **lcc-tools**, tools to construct and manipulate higher-dimensional linear cell complexes.
- 2010–now **pprepair**, (planar partition repair) ensures that a set of polygons form a valid planar partition, made of valid polygons and having no gaps or overlaps.
- 2010–now **pprepair**, (polygon repair) takes a possibly invalid polygon, gives it a consistent interpretation and returns a valid polygon according to the OGC Simple Features and ISO 19107 rules.

## Editorial board in journals

**International Journal of 3D Information Modeling**

## Scientific committee member in conferences

- 2018 **13th 3D GeoInfo Conference.** Delft, the Netherlands.
- 3rd International Conference on Smart Data and Smart Cities.** Delft, the Netherlands.
- ISPRS Technical Committee IV Symposium 2018.** Delft, the Netherlands.

- 2017 **12th 3D Geoinfo Conference.** Melbourne, Australia.  
**2nd International Conference on Smart Data and Smart Cities.** Puebla, Mexico.  
**4th International GeoAdvances Workshop on Multi-dimensional & Multi-scale Spatial Data Modeling.** Karabük, Turkey.  
**3rd International Workshop on Indoor 3D.** Wuhan, China.  
**ISPRS Workshop on Modelling and Managing Cartographic Data.** Washington, United States.  
**AGILE 2017 Pre-conference Workshop on Bridging Space, Time, and Semantics in GIScience.** Wageningen, the Netherlands.  
**GRASF Conference 2017.** Dubai, United Arab Emirates.
- 2016 **4th Eurographics Workshop on Urban Data Modelling and Visualisation.** Liège, Belgium.  
**11th 3D Geoinfo Conference.** Athens, Greece.  
**2nd International Conference in 3D Indoor Modelling and Navigation.** Athens, Greece.
- 2015 **WITCOM 2015, Conferences and Workshops in Telematics and Computing.** Mexico City, Mexico.  
**3rd Eurographics Workshop on Urban Data Modelling and Visualisation.** Delft, the Netherlands.
- 2014 **1st International Congress on Telematics, Computing and Communications.** Mexico City, Mexico.

## Reviews in journals

**Environmental Pollution** (2018)  
**Sensors** (2018)  
**Transactions on Spatial Algorithms and Systems** (2017)  
**Remote Sensing** (2017)  
**ISPRS International Journal of Geo-Information** (2016, 2017, 2018)  
**Journal of Geographical Systems** (2016, 2018)  
**International Journal of Geographical Information Science** (2015, 2016, 2017)  
**International Journal of 3D Information Modeling** (2014, 2016, 2018)  
**Transactions in GIS** (2013, 2014, 2015, 2016, 2017, 2018)  
**Computers & Geosciences** (2012, 2013, 2014, 2015, 2016, 2017, 2018)

## Skills

### Computer-related

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|-------------------|---|
| Operating Systems | Familiar with all recent versions of Windows, Mac OS and various Linux distributions. Others as a user, but with little programming experience.   |
| Programming       | Familiar with C, C++, CSS, HTML, Objective-C, PHP, Python and Ruby. Others in a lesser degree (e.g. Java, Javascript, Lisp, Matlab, Scheme, Perl, Prolog). Use of other relevant software, libraries and frameworks for computational geometry (e.g. CGAL, openCASCADE), graphics and visualisation (e.g. OpenGL), debugging and unit testing, parsing, I/O in various file formats, and user interfaces, among others. |
| Software          | Various office suites (e.g. iWork, MS Office and OpenOffice.org), databases (e.g. MySQL, Oracle and PostgreSQL) with spatial extensions, web servers (Apache and nginx), typesetting with (Xe)LaTeX, image editing packages and drawing programs (e.g. Aperture, OmniGraffle and Adobe Photoshop), among others.  |

### Languages

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| Spanish  | native speaker                               |
| English  | expert (IELTS 8.5 and paper based TOEFL 670) |
| Japanese | intermediate (3-kyu)                         |
| Dutch    | intermediate                                 |

## References

Available upon request