

Curriculum Vitae of Remco Duits

Personal Data

Name: R.Duits (Remco)
 Birth Date & Place: 26-05-1978, Weert, The Netherlands
 Nationality: Dutch
 Partner: Tamara Nijsen, 18-01-1979,
 Children: Kyra Duits (daughter) 08-07-2011 & Tom Duits (son) 29-01-2013.

Affiliation

Dr.ir. R.Duits
 Eindhoven University of Technology (TU/e)
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Educational Background

1996–2001: Eindhoven University of Technology, Department of Mathematics and Computer Science.
 Master degree in Applied Mathematics (5 year study) August 2001. Industrial master project on the application of matrix groups in geodesy, <http://alexandria.tue.nl/repository/books/716743.pdf>, rewarded with maximum grade of 10. Master thesis (**Honors: cum laude**) on a new functional analytical approach to the Stokes boundary value problem, <http://alexandria.tue.nl/extra2/afstversl/wsk-i/duits2001.pdf>

Research Experience and Former Affiliations

01-09-2001–01-09-2005: **PhD** degree in biomedical engineering at Eindhoven University of Technology. PhD thesis: “Perceptual Organization in Image Analysis—a Mathematical Approach based on Scale, Orientation and Curvature”, www.bmia.bmt.tue.nl/people/rduits/THESISRDUIITS.pdf.

Honors: cum laude (best thesis of the biomedical engineering dep. in 2005, nominated for the ASML promotion prize of best PhD thesis at TU/e, i.e. among 2% best, in 2005)

01-09-2005–01-04-2006: **Postdoc** at the biomedical engineering department within the biomedical image analysis (BMI/a, www.bmia.bmt.tue.nl) group of Prof. Bart ter Haar Romeny at TU/e.

01-04-2006–01-08-2015: **Assistant Professor** (UD), fixed-term position,

01-08-2015–Now: **Associate Professor** (UHD), fixed-term position, both within the Center for Analysis, Scientific Computing and Applications (CASA, www.win.tue.nl/casa) headed by Prof. Mark Peletier, Prof. Barry Koren and Prof. Luc Florack at the Department of Mathematics and Computer Science at the TU/e. Within this position R.Duits is affiliated part-time (0.1 fte) to the biomedical engineering department for applying his theory to medical imaging applications. Long-term visits to excellent international research institutes abroad include:

- October, 2002: Collaborative visit to Prof. Stephen Pizer, Dep. of Computer Science, and Prof. James Damon, Dep. of Mathematics, University of North Carolina Chapel Hill, USA.
- November, 2004: Collaborative visit to Prof. Michael Felsberg, Computer Vision Laboratory, Linköping University, Linköping, Sweden.
- March & April, 2006: Collaborative visit to Prof. David Mumford (fields medal winner), Brown University, Div. Applied Mathematics, USA, to discuss my solutions to his problem in his paper *elastica and computer vision* generating QAM-AMS publications on exact solutions of left-invariant PDE's on $SE(2)$. Meanwhile we extended all our solutions of the linear left-invariant PDE's to the case $SE(3)$.
- June 2007: Collaborative visit to Prof. Joachim Weickert, and Dr. Bernard Burgeth, Mathematical Image Analysis group of Saarland University, Germany, to discuss novel crossing preserving nonlinear diffusions.
- March 2008: Collaborative visit to Prof. Michael Felsberg, Computer Vision Laboratory, to collaborate on orientation scores in imaging and orientation channels in robotics. Linköping University, Sweden.

- April, May, June 2008, March 2009: Collaborative visit to Prof. Harmut Führ, Lehrstuhl für die Mathematik A, RWTH Aachen, Germany, for collaborations regarding left-invariant evolutions on Gabor transforms, yielding a publication in ACHA.
- April 2012, collaborative visit to Prof. U.Boscain and S.Mallat, Ecole Polytechnique Paris, CMAP, France, generating two joint publications in JMIV and ESAIM Control and Optimization.
- May 2013, collaborative visit to dr. A. Sarti and dr. G. Citti, CAMS EHESS, France, for joint collaborations on both metric analysis and numerics of left-invariant evolutions on the roto-translation group within the recently granted EU-Marie Curie project MANET (ag.no. 607643).

Teaching Experience and Supervision

- responsible teacher of TU/e course *Mathematical Modeling in Physiology (2DX00)* yearly 2006–2014.
- responsible teacher of TU/e math course *Applied Functional Analysis (2WA08)* yearly 2006–2014.
- responsible teacher of TU/e math course *Wiskunde II (2DM60)* for biomedical engineering, 2013.
- teacher of TU/e calculus and (image) analysis courses (2DM00,2WBB0,8G116,2Y060), 2006–2013.
- tutor at many design-based learning projects at TU/e, 2001–2006.
- teacher of *Orientation Score Theory and its Solutions to Cortical PDE, ODE and Wavelet Models* in for UNIBO (Bologna) CAMS-EHESS (Paris) www.bmia.bmt.tue.nl/people/RDuits/cort.pdf, Italy 2017.

BKO certificate on didactic skills obtained in 2012 at dep. of Mathematics and Computer Science TU/e. Associate Professor certificate on Academic Leadership obtained in 2017 at TU/e. I have successfully supervised:

- 6 PhD projects (Erik Franken & Erik Bekkers & Bart Janssen & Jiong Zhang & Stephan Meesters & Jorg Portegies) of which 2 were cum laude ($\leq 5\%$ best) and 3 nominated (Bekkers, Franken, Janssen) as best of the departments (W&I and BME) for prize yearly best TU/e PhD thesis. The most recent PhD thesis is by Jorg Portegies: www.bmia.bmt.tue.nl/people/RDuits/Jorg.pdf
- 15 master projects, of which 8 were rewarded cum laude, and 7 trainingship image analysis projects.

and 4 post-doc projects (Sanguinetti & Mashtakov & Bekkers & Portegies). Current supervision: 2 PhD students (finishing in 2018), 1 post-doc, 1 scientific programmer, 1 master student, 1 bachelor student project at the TU/e.

Other Professional Activities

- organizer and chair on three international workshops held at Eurandom TU/e (www.eurandom.tue.nl/). These workshops are intended for both mathematicians (probability theory, harmonic analysis and statistics) and mathematically inclined engineers (statistics and imaging):
 - Dec.11-13,2006 : *Image Analysis and Inverse Problems* organized by Laurie Davies, Remco Duits and Marie-Colette van Lieshout.
 - Sept.24-26,2007 : *Algorithms in Complex Systems* organized by Laurie Davies, Remco Duits, Geurt Jongbloed and Marie-Colette van Lieshout.
 - Nov.24-26,2008 : *Locally Adaptive Filters in Signal and Image Processing* organized by Laurie Davies, Remco Duits, Luc Florack, Geurt Jongbloed and Marie-Colette van Lieshout.
- member of several programme committees, e.g. of the international conferences on scale space and variational methods 2007, 2009, 2011, 2013 and Dagstuhl seminar 11501 in 2012.
- Main organizer of workshop “*Image Analysis and Control Theory*” in august 2011 at the TU/e to bridge the fields of geometric control theory and image analysis.
- Main organizer of large workshop “*Geometry, PDEs and Lie Groups in Image Analysis*”, august 2016. www.bmia.bmt.tue.nl/people/RDuits/workshop/index.html
- Main organizing committee member of the yearly math congress ‘Nieuw Mathematisch Congress’ by the Royal Dutch Mathematics Association (KWG) 2018.
- member of the EMaCs organizing committee.EMaCs (Eindhoven Mathematics Colloquiums, 2010-2013).
- associate editor in editorial board for JMIV since 1-1-2016.
- organising editor special issue (JMIV 2017) ‘Differential Geometry & Orientation Analysis for Image Processing’
- regular scientific reviewing for journals such as JMIV, IJCV, PAMI, *Journal of Physiology*, SIAM Journal on Imaging Science, and IEEE-journal *TMI* etc.

- program committee member and scientific reviewer of several conference proceedings and related books, e.g. the proceedings of the conference on scale space and variational methods (2005–2017), Eurandom workshops, Vis2010, CDMRI, Dagstuhl seminars, GSI-2017, etc.
- scientific reviewer of research proposals in the European Union (EU-Marie Curie project), and France (Agence Nationale de la Recherche, ANR).
- committee member of 8 PhD and 20 MsC projects, rapporteur of PhD Laurent Sifre (invited by Prof. Stephane Mallat) EP-CMAP Paris, rapporteur of PhD Chen Da (invited by Prof.L.Cohen) Paris Dauphine.
- member of the Institute For Diagnostic and Interventional Imaging (IMDI-IDII) within Innovative medical Devices Initiative: active collaborations/publications/joint projects with Epilepsy Institute Kempenhaghe b.v. and Utrecht University (with P. Ossenkop & A. Leemans).
- member of the national Advanced School for Computing and Imaging (ASCI), active collaborations and joint projects with TU-Delft (with dr. M. Loog & dr. A. Vilanova).
- 3TU AMI TU/e-Health coordination August 2013–April 2014 and co-organizer of joint-research day for cross collaborations between dutch technical universities on theme health (medical imaging).
- active participation in image analysis projects Study Group Weeks Industrial Mathematics (e.g. *Imaging Recognition of Shape Defects in Hot Steel Rolling for TATA-steel* in SWI 2012 proc.).
- industrial collaborations via joint projects with *I-optics* (with T. van Elzaker) *Inviso b.v.* (with dr. F. Kanter), *Philips Healthcare* (with Prof. M. Breeuwer), *Philips X-ray Interventions* (with dr. J. Olivan Bescos).
- for an overview of invited presentations see www.bmia.bmt.tue.nl/people/rduits/presentations.pdf

Funding ID

Currently involved as main applicant in the approved research grants :

- European Research Council 2013-2018 ERC-Stg (personal grant). Title: **Lie Analysis**, (no. 335555). Full title: *Lie Group Analysis for Medical Image Processing*.
- EU-Marie Curie (FP7-PEOPLE-2013-ITN), Title: **MANET** (no. 607643). Full Title: *Metric Analysis and Emerging Technologies*.

Previously involved as co-applicant in: IST/e High Potential Program TU/e, Image Science and Technology, and in EU-Marie Curie FIRST (ag.no. PITN-GA-2009-238702).

Publications

Type of Publication	#
peer-reviewed international journals	38
peer-reviewed conferences proceedings	46
abstracts with code release	2
book chapters	4
books	2

All publications contain novelties both on the theoretical as on the application side. Close multi-disciplinary collaborations helped me to bring novel mathematical theory (e.g. [RD2–4]) to medical imaging applications.

Key publications are available on my homepage: <http://bmia.bmt.tue.nl/people/RDuits/>.

For the complete list of **92** publications see: <http://bmia.bmt.tue.nl/people/RDuits/complete.pdf>.

Number of citations: **1663**, h-index: **22**, i-10 index: **42**, according to *Google scholar*.

Journal publications take place in two different types of journals:

- International Mathematical Journals, e.g. *Quarterly of Applied Mathematics*, A.M.S. (4 times) and (ACHA), *Applied Computational Harmonic Analysis* (2 times), (DGA) *Differential Geometry and Applications*, *E-SAIM: Control, Optimisation & Calculus of Variations*, *JDCS: Journal of Dynamical Control Systems*.
- International Image analysis journals: e.g. (IJCV), *International Journal of Computer Vision* (6 times), and *JMIV Journal of Mathematical Imaging and Vision* (5 times), *SIAM-SIIMS SIAM Journal on Imaging Sciences*, *IEEE-TMI Trans. on Medical Imaging* and *IEEE-PAMI Pattern Rec. & Machine Intelligence*.

and are either induced by personal invitation via best paper selections at conferences (e.g. Early Cognitive Vision Workshop 2005, PRIA 2004, Scale Space and Variational Methods, 2003, 2005, 2007, 2009, 2011) or via international visits (e.g. to Prof. David Mumford, USA, to Prof. Hartmut Führ, Germany). The 44 conference articles have been reviewed (double-blindly) by at least 3 external reviewers, with low passing rates. They include 8 selected best papers [RD26,RD39,RD40,RD42,RD45,RD46,RD51,RD86] and 4 best paper awards [RD28,RD34,RD41,RD58]. Book [RD70] and chapters [RD71,RD72,RD74] relate to international workshops.

Selection Peer-reviewed Journal Publications:

[RD 2] R. Duits and M. van Almsick, “The explicit solutions of linear left-invariant second order stochastic evolution equations on the 2d-Euclidean motion group,” *Quarterly of Applied Mathematics, American Mathematical Society*, vol. 66, pp. 27–67, April 2008.

[RD 3] R. Duits and E. M. Franken, “Left invariant parabolic evolution equations on $SE(2)$ and contour enhancement via invertible orientation scores, part I: Linear left-invariant diffusion equations on $SE(2)$,” *Quarterly of Applied mathematics, AMS*, vol. 68, pp. 255–292, June 2010.

[RD 4] R. Duits and E. Franken, “Left invariant parabolic evolution equations on $SE(2)$ and contour enhancement via invertible orientation scores, part II: Nonlinear left-invariant diffusion equations on invertible orientation scores,” *Quarterly of Applied mathematics, AMS*, vol. 68, pp. 293–331, June 2010.

[RD 1] R. Duits, L. M. J. Florack, J. de Graaf, and B. M. ter Haar Romeny, “On the axioms of scale space theory,” *Journal of Mathematical Imaging and Vision*, vol. 20, pp. 267–298, 2004.

[RD 5] R. Duits, M. Felsberg, G. Granlund, and B. M. ter Haar Romeny, “Image analysis and reconstruction using a wavelet transform constructed from a reducible representation of the Euclidean motion group,” *International Journal of Computer Vision*, vol. 79, no. 1, pp. 79–102, 2007.

[RD 8] R. Duits and E. M. Franken, “Left-invariant diffusions on the space of positions and orientations and their application to crossing-preserving smoothing of HARDI images.,” *International Journal of Computer Vision* vol. 92, pp. 231–264, March 2011.

[RD 11] E. M. Franken and R. Duits, “Crossing preserving coherence-enhancing diffusion on invertible orientation scores,” *International Journal of Computer Vision*, vol. 85, no. 3, pp. 253–278, 2009.

[RD 13] R. Duits, H. Führ, B.J. Janssen, M. Bruurmijn, L.M.J. Florack and H.A.C.van Assen, “Evolution Equations on Gabor Transforms and their Applications”, *ACHA*, pp. 483–526, november 2013.

[RD 17] R.Duits, T.C.J.Dela Haije, E.J. Creusen and A.Ghosh, “Morphological and Linear Scale Spaces for Fiber Enhancement in DW-MRI”, *JMIV*, vol(46), pp.326-368, 2013.

[RD 18] U. Boscain, R. Duits, F. Rossi and Y. Sachkov, “Curve Cuspless Reconstruction via sub-Riemannian Geometry” *ESAIM-COCV Control Optimization and Calculus of Variations.*, vol. 20, pp.748–770, 2014.

[RD 19] E.J. Bekkers, R. Duits, T. Berendschot, B.M. ter Haar Romeny, “A Multi-Orientation Analysis Approach to Retinal Vessel Tracking.,” *Journal of Math. Imaging and Vision*, vol. 49, no. 3 pp. 583–610, 2014.

[RD 20] R.Duits, U.Boscain, F.Rossi and Y.Sachkov, “Association Fields via Cuspless Sub-Riemannian Geodesics in $SE(2)$.” *JMIV*, Published online (open access) Dec. 2013. Vol. 49 (2), pp. 384-417, 2014.

[RD 24] J.Portegies, R.Fick, G.R.Sanguinetti, S.P.L.Meesters, G.Girard and R.Duits. “Improving Fiber Alignment in HARDI by Combining Contextual PDE flow with Constrained Spherical Deconvolution.” Accepted for open access publication in *PlosOne* 2015. www.bmia.bmt.tue.nl/people/RDuits/mainJorg.pdf

[RD 23] J. Zhang* & R. Duits* (*joint main authors), G.R. Sanguinetti, B.M.ter Haar Romeny. “On Numerical Approaches for Linear Left-invariant Diffusions on $SE(2)$, their Comparison to Exact Solutions, and their Applications in Retinal Imaging.” vol. 9, p.1-50, 2016. www.bmia.bmt.tue.nl/people/RDuits/ZhangDuits.pdf

[RD 25] E.J. Bekkers* and R.Duits* and A.Mashtakov* and G.R.Sanguinetti* (*joint main authors). “A PDE Approach to Data-Driven Sub-Riemannian Geodesics” *SIAM Journal on Imaging Sciences (SIIMS)*, vol 8, (4), p.2740–2770, 2015. <http://bmia.bmt.tue.nl/people/RDuits/siims.pdf>

[RD 88] Duits, R., Meesters, S., Mirebeau, J.M. and Portegies, J.M. *Optimal Paths for Variants of the 2D and 3D Reeds-Shepp Car with Applications in Image Analysis* to JMIV 2017, see <https://arxiv.org/abs/1612.06137>.

[RD 26] R. Duits* & M.H.J. Janssen* (*joint main authors), J. Hannink, G. Sanguinetti. “Locally Adaptive Frames in the Roto-translation Group and their Applications in Medical Imaging.” *Journal of Mathematical Imaging and Vision*, vol 56, (3), p.367–402, 2016.

[RD 87] Portegies, J.M. and Duits, R. *New Exact and Numerical Solutions of the (Convection-)Diffusion Kernels on $SE(3)$* Accepted. To appear in DGA, Differential Geometry and Applications, 2017. For preprint see <http://bmia.bmt.tue.nl/people/RDuits/SE3JorgPortegiesDuits.pdf> or <https://arxiv.org/abs/1604.03843>

[RD 81] R. Duits, A. Ghosh, T.C.J. Dela Haije and A. Mashtakov. *On sub-Riemannian Geodesics within $SE(3)/(\{0\} \times SO(2))$ whose spatial projections do not have cusps.* Journal of Dynamical Control Systems (JDCS), 22(4), p.771–805, 2016.

Selection Peer reviewed proceedings/conference publications:

[RD 27] R. Duits, T. C. J. Dela Haije, A. Ghosh, E. J. Creusen, A. Vilanova, and B. ter Haar Romeny, “Enhancement of DW-MRI,” in *Scale Space and Variational Methods in Computer Vision (Lecture Notes in Computer Science)*, vol. 6667, pp. 1–13, September 2011.

[RD 28] R. Duits and B. Burgeth, “Scale spaces on Lie groups,” in *Scale Space and Variational methods* (M. Sgallari and Paragios, eds.), (Ischia, Italy), pp. 300–312, 2007.

[RD 62] J. Hannink, R. Duits, and E.J. Bekkers, *Crossing-Preserving Multi-Scale Vesselness MICCAI* at the main conf. proc. Boston 2014, LNCS 8674, pp.603–610, 2014.

Selection Books and book chapters:

[RD 71] L. M. J. Florack, R. Duits, G. Jongbloed, M.-C. van Lieshout, and L. Davies, *Mathematical Methods for Signal and Image Analysis and Representation*. Springer-Verlag, Berlin, 2012.

[RD 72] R. Duits, H. Führ, and B. Janssen, *Left Invariant Evolution Equations on Gabor Transforms*, chapter 8 in book [RD 70], pp. 151–172. Springer-Verlag, 2012.

[RD 75] R. Duits, A.Ghosh, T.C.J. Dela Haije, Y.L. Sachkov, *Cuspless Sub-Riemannian Geodesics within the Euclidean Motion Group $SE(d)$* , in *Neuromathematics of Vision*, Springer Series Lecture Notes in Morphogenesis, vol.1 p.173–240, 2014.

Invited Presentations and Awards

The list of invited international presentations can be found on my website <http://bmia.bmt.tue.nl/people/RDuits/presentations.pdf>. They include 34 invited talks/visits at prestigious institutes (e.g. Ecole Polytechnique & Henri Poincare Inst. Paris, WIAS Berlin, Brown University USA, Helmholtz Zentrum München) and international conferences (such as Scale Space and Variational Methods). Awards:

- *Cum laude* reward and selected as best of the department for TU/e promotion prize (i.e. among the 2% best at TU/e) for PhD-thesis in 2005 [RD52].
- *Cum laude* reward for Master thesis (supervised by Prof. J. de Graaf) on a new functional analytic approach to Stokes problems in 2001.
- Industrial master project in company *Geodelta* in Delft in 2001 on “Application of Orthogonal Matrix Groups in Geodesy”, was rewarded with maximum grade of 10.
- *Best Paper Award* on MMBIA workshop ICCV 2007 (Brasil) yielding invited submission [RD11] to International Journal of Computer Vision (IJCV).
- *Best Paper Award* on Scale Space conference (Scotland) 2003 yielding invited submission [RD12] to IJCV.
- *Best Paper Award* on PRIA Conference 2006 (Russia) yielding invited submission to Image Processing, Analysis, Recognition and Understanding [RD7].
- *Best PhD-thesis award* of the department Biomedical Engineering, TU/e, 2005. Nominated for best PhD-thesis award of all departments of TU/e (ASML-promotion prize), 2005.
- *Selected paper* on Scale Space and Variational Methods (SSVM) conf. 2007 (Italy) for invited submission [RD10] to IJCV.
- *Selected paper* on Cognitive Vision Workshop (Scotland) 2005 for invited submission [RD5] to IJCV.
- *Selected paper* on SSVM conference 2009 (Norway) for invited submission, [RD8], to IJCV.
- *Selected paper* on SSVM conf. 2011 (Israel) for invited submission [RD17] to JMIV.
- *cum laude ISMRM Merit Award* for [RD55] & *Best Poster Award* at ICTOpen 2015, presenting [RD23].
- Copromotor and main supervisor of specially acknowledged PhD theses:
 - E. Franken (cum laude 2% best, selected as best of dep. for ASML prize) “Enhancement of Crossing Elongated Structures in Images”, <http://www.bmia.bmt.tue.nl/people/EFranken/PhDThesisErikFranken.pdf>.
 - B. J. Janssen (nominated for ASML-prize) on “Representation and Manipulation of Images Based on Linear Functionals”, <http://www.win.tue.nl/casa/research/casaprojects/janssen.html>.
 - E.J. Bekkers (cum laude $\leq 2\%$ best, selected as best of 2 departments: Dep. Math. & Comp. Science and Dep. of Biomedical Eng. for the TU/e promotion prize 2017) “Retinal Image Analysis using Sub-Riemannian Geometry in $SE(2)$ ”, http://erikbekkers.bitbucket.io/data/pdf/Bekkers_PhD_Thesis.pdf
- *Selected paper* [RD86] on SSVM conf. 2017 (Denmark) for invited submission to JMIV.
- *Best Referee Award* at SSVM 2015.
- *Keynote speaker* at SSVM 2011 (Israel).