dr. ir. Erik J. Bekkers

Assistant Professor at the Amsterdam Machine Learning Lab (AMLab), University of Amsterdam

🏠 Von Rheinhabenstraat 4, 5213SP, 's-Hertogenbosch, the Netherlands
☎ +31-646733650 ✉ e.j.bekkers@uva.nl 🐦 @erikjbekkers

PRINCIPAL INTERESTS
Geometry-grounded representation learning, geometric deep learning, generative modeling, (differential) geometry in machine learning, medical image analysis, computational chemistry, neurogeometry of vision.

ACADEMIC BACKGROUND

Assistant Professor   2019 - Present
University of Amsterdam, AMLab, Amsterdam, Netherlands

- Supervising 6 Ph.D. students on fundamental (geometric) deep learning methods (equivariant architectures, geometric graph NNs, uncertainty quantification) with applications in medical image analysis and computational chemistry.

- Research on geometry- and context-aware AI (NWO veni grant)

- Teaching in the Master AI. Coordinator for Machine Learning 1, the Deep Learning 2 module on Group Equivariant Deep Learning, and a brush-up course ML for Medical Informatics.

- Vice-chair in the board of examiners B.Sc. and M.Sc. Artificial Intelligence.

Post-doc   2016 - 2019
Eindhoven University of Technology, Applied Differential Geometry, Eindhoven, NL

- Co-supervising PhD students in the ERC-StG "Lie Analysis" project of dr.ir. Remco Duits at the dept. of Applied Mathematics and Computer Science.

- Research in ML and image analysis algorithms for medical images using geometric mathematical techniques. Special focus on the analysis, tracking and segmentation of curvilinear structures (lines, vessels, neurons) in 2D and 3D.

- Teaching graduate and undergraduate level Applied Mathematics and Computer Science such as Linear Algebra, PDEs, Mathematical Image Analysis.

- Secretary for the department council for the department of Mathematics and Computer Science.

Ph.D. (Cum-Laude) Medical Image Analysis - Biomedical Engineering   2013 - 2017
Eindhoven University of Technology, Eindhoven, the Netherlands

- Ph.D. research in brain-inspired algorithm development based on the differential geometry of Lie groups, under direction of dr.ir. Remco Duits and prof. dr. em. Bart ter Haar Romeny. Dissertation title: Retinal Image Analysis using Sub-Riemannian Geometry in SE(2).

- This was an industrial Ph.D. with i-Optics (EasyScan BV).

M.Sc. Biomedical Engineering   2010 - 2012
Eindhoven University of Technology, Eindhoven, the Netherlands

- Focus areas: medical image analysis and physics of imaging. Thesis (vessel tracking in orientation scores) with University Eye Clinic Maastricht. Internships at Osaka University, Japan (5 months) and at Philips Research (3 months).

AWARDS AND RECOGNITION

- 2025 - *NWO vidi grant*, 850k personal grant by the Dutch Research Council
- 2023 - *ELLIS Scholar* within the Geometric Deep Learning program
- 2022 - University of Amsterdam *Lecturer of the Year*, Faculty of Science
- 2019 - *NWO veni grant*, 250k personal grant by the Dutch Research Council
- 2018 - *Young Scientist Award* awarded by the Medical Image Computing and Computer Assisted Interventions (MICCAI) society.
- 2018 - *Philips Impact Award* awarded at the international conference on Medical Imaging with Deep Learning (MIDL).
- 2018 - TU/e university-wide *Best Ph.D. Thesis Nomination*.
- 2017 - *Cum Laude* Ph.D. thesis.

PROFESSIONAL ACTIVITIES

Professional activities/Service to the research field

- 2024 - Organizer of the ICML'24-GRaM Workshop on Geometry-grounded representation learing and generative modeling.
- 2023 - Organizer of the session on *Neurogeometry meets Geometric Deep Learning* at Geometric Science of Information 2023 together with Remco Duits (TU/e) and Alessandro Sarti (CNRS)
- 2023 - Joined management committee of Horizon Europe Cost Action Cartan geometry, Lie, Integrable Systems, quantum group Theories for Applications (CaLISTA)
- 2022 - Organizer of the international workshop on Geometric Deep Learning for Medical Image Analysis 2022 (GeoMedIA 2022) together with Angelica Avilez-Rivero (Cambridge) and Jelmer Wolterink (Uni Twente)
- 2022 - Organizer and Lecturer at Tutorial on Geometric Deep Learning in Medical Image Analysis at MICCAI 2022 together with Angelica Avilez-Rivero (Cambridge) and Jelmer Wolterink (Uni Twente)
- 2022 - Organizer of the session on *Geometric Deep Learning* at Geometric Science of Information 2021 together with Gabriel Peyre (CNRS, École Normale Supérieure)
- 2022 - Recorded and released lectures on Group Equivariant Deep Learning. The Youtube playlist has over 17,000 views.
- 2021 - Lecturer at Danish Summer School on Geometric Deep Learning
- 2021 - Recorded and released lectures on Machine Learning. The Youtube playlist has over 67,000 views.
- 2020 - Organizer of ELLIS workshop on Geometric and Relational DL together with Thomas Kipf (Google Brain)
- 2016 - Organizer of 3-day International Workshop on Geometry, PDE's and Lie Groups in Image Analysis together with Remco Duits (TU/e), Andrea Fuster (TU/e) and Yuri Sachkov (RAS)
- Ongoing - Reviewer and area chair for conferences ICLR, NeurIPS, ICML, MICCAI, and ad-hoc for conferences/workshops like CVPR, NeuIPS-Neurreps, LoG Conference and journals like IEEE tPAMI, TMI, IJCV, JMIV, MedIA, among others.
- Ongoing, ELLIS member and faculty of ELLIS unit Amsterdam.

Invited Talks (selection)

- 2024 - Invited talk at the Chairs Structured Learning workshop.

- 2024 - Keynote speaker at the CVPR'24 - Equivision workshop.
- 2023 - Invited talk SIAM CSE Amsterdam, session on Geometry and Shape Analysis for Neuroscience: Geometric Structures in Neuroscience.
- 2022 - Invited talk at Neurips 2022 workshop Neurreps: Symmetry and Geometry in Neural Representations, New Orleans, US
- 2022 - Invited talk at Workshop on Geometry and Machine Learning, Heidelberg, DE
- 2021 - Keynote at Computational Mathematics and Machine Learning, Lorentz Centre, Leiden
- 2020 - Invited talk at LMS-Bath Symposium Mathematics of Machine Learning, Bath, UK
- 2019 - Invited talk at ICCV 2019 4th workshop on Geometry Meets Deep Learning Workshop, Seoul, KR

RESEARCH FUNDING

The following research proposals have been granted

- 850K euro (2024) - *as sole applicant* - NWO vidi (Exact sciences) for project "Neural Ideograms: Shaping AI with Geometry-Grounded Learning"
- 775K euro (2023) - *as co-applicant* - KWF Public Private Partnership for the project "Artificial Intelligence based and integrated histopathology image analysis for personalized immunotherapy selection of Gastric and Esophageal cancer patients (SELECT-AI)" with Sybren Meijer at AUMC, and Ellogon AI.
- 2.5M euro (2023) - *as co-applicant* - Participating with 1 PhD student (out of 11) in a Horizon Europe Marie Sklodowska-Curie consortium led by Rita Fioresi at University of Bologna on "Cartan and differential geometry, Lie theory, quantum groups and non commutative geometry For novel and Innovative Applications to quantum algorithms and geometric deep learning"
- 250K euro (2021) - *as co-applicant* - MLDS "Right on Time" Research fund by the Maag Lever Darm Stichting for "Artifical Intelligence based Detection and progression-prediction of Esophageal Adenocarcinoma precursor Lesions (IDEAL)". Main PI is Sybren Meijer, pathologists at the Amsterdam University Medical Center. The grant allowed us to fund Ph.D. student Michel Botros which is jointly affiliated with AUMC and UvA.
- 250K euro (2019) - *as sole applicant* - NWO veni (Applied engineering sciences) for project "Context-Aware Artificial Intelligence in Medical Image Analysis"

TEACHING (at UvA)

- University of Amsterdam *Lecturer of the Year* Faculty of Science 2022
- Received University Teaching Qualification (BKO) in 2022
- Courses:
    - *Machine Learning 1, M.Sc. AI*   *2020-present*
    - *Deep Learning 2: Equivariant Deep Learning, M.Sc. AI*   *2022-present*
    - *Brush-up Machine Learning, M.Sc. Medical Informatics*   *2022-present*
- Graded 40+ M.Sc. thesis projects
- Supervised 22 M.Sc. students

CONFERENCE PUBLICATIONS   See also my Google Scholar page for an up-to-date overview.

[1] E. J. **Bekkers**, S. Vadgama, R. Hesselink, P. A. V. d. Linden, and D. W. Romero. "Fast, Expressive SE(n) Equivariant Networks through Weight-Sharing in Position-Orientation Space". In: *The Twelfth International Conference on Learning Representations*. 2024.

[2] M. M. Islam, C. d. Vente, B. Liefers, C. Klaver, E. J. **Bekkers**, and C. I. Sánchez. "Uncertainty-aware retinal layer segmentation in OCT through probabilistic signed distance functions". In: *Medical Imaging with Deep Learning*. 2024.

[3] M. M. Kofinas, E. J. **Bekkers**, N. Nagaraja, and E. Gavves. "Latent field discovery in interacting dynamical systems with neural fields". In: *Advances in Neural Information Processing Systems*. Vol. 36. 2024.

[4] T. P. Kuipers, P. R. Konduri, H. Marquering, and E. J. **Bekkers**. "Generating Cerebral Vessel Trees of Acute Ischemic Stroke Patients using Conditional Set-Diffusion". In: *Medical Imaging with Deep Learning*. 2024.

[5] F. Eijkelboom, R. Hesselink, and E. J. **Bekkers**. "E(n) Equivariant Message Passing Simplicial Networks". In: *International Conference on Machine Learning*. PMLR, 2023, pp. 9071–9081.

[6] D. M. Knigge, D. W. Romero, A. Gu, E. Gavves, E. J. **Bekkers**, J. M. Tomczak, M. Hoogendoorn, and J.-j. Sonke. "Modelling Long Range Dependencies in ND: From Task-Specific to a General Purpose CNN". In: *International Conference on Learning Representations*. Feb. 2023.

[7] T. P. Kuipers and E. J. **Bekkers**. "Regular SE(3) Group Convolutions for Volumetric Medical Image Analysis". In: *Medical Image Computing and Computer Assisted Intervention – MICCAI 2023*. Ed. by H. Greenspan, A. Madabhushi, P. Mousavi, S. Salcudean, J. Duncan, T. Syeda-Mahmood, and R. Taylor. Cham: Springer Nature Switzerland, 2023, pp. 252–261.

[8] S. Vadgama, J. M. Tomczak, and E. J. **Bekkers**. "Continuous Kendall Shape Variational Autoencoders". In: *Geometric Science of Information*. Ed. by F. Nielsen and F. Barbaresco. Cham: Springer Nature Switzerland, 2023, pp. 73–81.

[9] J. Brandstetter, R. Hesselink, E. Pol van der, E. J. **Bekkers**, and M. Welling. "Geometric and Physical Quantities improve E(3) Equivariant Message Passing". In: *International Conference on Learning Representations*. 2022.

[10] D. M. Knigge, D. W. Romero, and E. J. **Bekkers**. "Exploiting redundancy: Separable group convolutional networks on lie groups". In: *International Conference on Machine Learning*. PMLR, 2022, pp. 11359–11386.

[11] D. W. Romero, R.-J. Bruintjes, J. M. Tomczak, E. J. **Bekkers**, M. Hoogendoorn, and J. v. Gemert. "FlexConv: Continuous Kernel Convolutions With Differentiable Kernel Sizes". In: *International Conference on Learning Representations*. 2022.

[12] D. W. Romero, A. Kuzina, E. J. **Bekkers**, J. M. Tomczak, and M. Hoogendoorn. "CKConv: Continuous Kernel Convolution For Sequential Data". In: *International Conference on Learning Representations*. 2022.

[13] R. Duits, B. M. N. Smets, E. J. **Bekkers**, and J. Portegies. "Equivariant Deep Learning via Morphological and Linear Scale Space PDEs on the Space of Positions and Orientations." In: *International Conference on Scale Space and Variational Methods in Computer Vision*. 2021, pp. 27–39.

[14] D. Romero, E. J. **Bekkers**, J. Tomczak, and M. Hoogendoorn. "Attentive group equivariant convolutional networks". In: *International Conference on Machine Learning*. PMLR, 2020, pp. 8188–8199.

[15] E. J. **Bekkers**. "B-Spline CNNs on Lie groups". In: *International Conference on Learning Representations*. 2019.

[16] F. Huang, S. Abbasi-Sureshjani, J. Zhang, E. J. **Bekkers**, B. Dashtbozorg, and B. M. ter Haar Romeny. "Vascular biomarkers for diabetes and diabetic retinopathy screening". In: *Computational Retinal Image Analysis*. Elsevier, 2019, pp. 319–352.

[17] E. J. **Bekkers**, M. W. Lafarge, M. Veta, K. A. J. Eppenhof, J. P. W. Pluim, and R. Duits. "Roto-Translation Covariant Convolutional Networks for Medical Image Anal-

ysis". In: *Medical Image Computing and Computer Assisted Intervention – MICCAI 2018*. Ed. by A. F. Frangi, J. A. Schnabel, C. Davatzikos, C. Alberola-López, and G. Fichtinger. Cham: Springer International Publishing, 2018, pp. 440–448.

[18] E. J. **Bekkers**, R. Duits, A. P. Mashtakov, and Y. L. Sachkov. "Vessel Tracking via Sub-Riemannian Geodesics on the Projective Line Bundle". In: *International Conference on Geometric Science of Information*. Springer, 2017, pp. 773–781.

[19] M. H. J. Janssen, T. C. J. Dela Haije, F. C. Martin, E. J. **Bekkers**, and R. Duits. "The Hessian of axially symmetric functions on SE (3) and application in 3D image analysis". In: *International Conference on Scale Space and Variational Methods in Computer Vision*. Springer, 2017, pp. 643–655.

[20] A. P. Mashtakov, R. Duits, Y. L. Sachkov, E. J. **Bekkers**, and I. Beschastnyi. "Sub-Riemannian geodesics in SO (3) with application to vessel tracking in spherical images of retina". In: *Doklady Mathematics*. Vol. 95. Springer, 2017, pp. 168–171.

[21] S. Abbasi-Sureshjani, I. Smit-Ockeloen, E. J. **Bekkers**, B. Dashtbozorg, and B. M. ter Haar Romeny. "Automatic detection of vascular bifurcations and crossings in retinal images using orientation scores". In: *Biomedical Imaging (ISBI), 2016 IEEE 13th International Symposium on*. IEEE, 2016, pp. 189–192.

[22] E. J. **Bekkers**, R. Duits, and M. Loog. "Training of Templates for Object Recognition in Invertible Orientation Scores: Application to Optic Nerve Head Detection in Retinal Images". English. In: *Energy Minimization Methods in Computer Vision and Pattern Recognition*. Ed. by X.-C. Tai, E. Bae, T. Chan, and M. Lysaker. Vol. 8932. Lecture Notes in Computer Science. Springer International Publishing, 2015, pp. 464–477.

[23] E. J. **Bekkers**, R. Duits, A. P. Mashtakov, and G. R. Sanguinetti. "Data-Driven Sub-Riemannian Geodesics". English. In: *International Conference on Scale Space and Variational Methods in Computer Vision*. Ed. by J.-F. Aujol, M. Nikolova, and N. Papakadis. Lecture Notes in Computer Science. Springer, 2015, pp. 613–625.

[24] G. R. Sanguinetti, E. J. **Bekkers**, R. Duits, M. H. J. Janssen, A. P. Mashtakov, and J.-M. Mirebeau. "Sub-Riemannian Fast Marching in SE(2)". In: *Progress in Pattern Recognition, Image Analysis, Computer Vision, and Applications*. Springer International Publishing, 2015, pp. 366–374.

[25] J. Zhang, E. J. **Bekkers**, S. Abbasi-Sureshjani, B. Dashtbozorg, and B. M. ter Haar Romeny. "Robust and Fast Vessel Segmentation via Gaussian Derivatives in Orientation Scores". English. In: *International Conference on Image Analysis and Processing 2015*. Ed. by G. Vernazza, E. Puppo, and V. Murino. Lecture Notes in Computer Science. 2015, pp. 537–547.

[26] E. J. **Bekkers**, R. Duits, and B. M. ter Haar Romeny. "Optic Nerve Head Detection via Group Correlations in Multi-orientation Transforms". English. In: *Image Analysis and Recognition*. Ed. by A. Campilho and M. Kamel. LNCS. Springer, 2014, pp. 293–302.

[27] J. Hannink, R. Duits, and E. J. **Bekkers**. "Crossing-Preserving Multi-scale Vesselness". English. In: *Medical Image Computing and Computer-Assisted Intervention – MICCAI 2014*. Ed. by P. Golland, N. Hata, C. Barillot, J. Hornegger, and R. Howe. Vol. 8674. Lecture Notes in Computer Science. Springer International Publishing, 2014, pp. 603–610.

WORKSHOP PUBLICATIONS

[28] V. Kovac, E. J. **Bekkers**, P. Lio, and F. Eijkelboom. "E(n) Equivariant Message Passing Cellular Networks". In: *ICML 2024 Workshop on Geometry-grounded Representation Learning and Generative Modeling*. 2024.

[29] V. Prins, W. Diepeveen, E. J. **Bekkers**, and O. Öktem. "Physics-informed geometric regularization of heterogeneous reconstructions in cryo-EM". In: *ICLR 2024 Workshop on Generative and Experimental Perspectives for Biomolecular Design*. 2024.

[30] O. Ranum, D. Wessels, G. Otterspeer, E. J. **Bekkers**, F. Roelofsen, and J. I. Andersen. "The NGT200 Dataset - Geometric Multi-View Isolated Sign Recognition". In: *ICML 2024 Workshop on Geometry-grounded Representation Learning and Generative Modeling*. 2024.

[31] R. A. Cosma, L. Knobel, P. van der Linden, D. M. Knigge, and E. J. **Bekkers**. "Geometric Superpixel Representations for Efficient Image Classification with Graph Neural Networks". In: *Proceedings of the IEEE/CVF International Conference on Computer Vision*. 2023, pp. 109–118.

[32] F. Eijkelboom, E. J. **Bekkers**, M. Bronstein, and F. Di Giovanni. "Can strong structural encoding reduce the importance of Message Passing?" In: *Proceedings of 2nd Annual Workshop on Topology, Algebra, and Geometry in Machine Learning (TAG-ML)*. Vol. 221. PMLR, 2023, pp. 278–288.

[33] Y. Koishekenov and E. J. **Bekkers**. "An Exploration of Conditioning Methods in Graph Neural Networks". In: *ICLR 2023 - Machine Learning for Drug Discovery workshop*. 2023.

[34] Y. Koishekenov, S. Vadgama, R. Valperga, and E. J. **Bekkers**. "Geometric Contrastive Learning". In: *4th Visual Inductive Priors for Data-Efficient Deep Learning Workshop*. 2023.

[35] P. A. Linden van der, D. W. Romero, and E. J. **Bekkers**. "Learned Gridification for Efficient Point Cloud Processing". In: *Proceedings of 2nd Annual Workshop on Topology, Algebra, and Geometry in Machine Learning (TAG-ML)*. Vol. 221. PMLR, 2023, pp. 9–20.

[36] A. Moskalev, A. Sepliarskaia, E. J. **Bekkers**, and A. Smeulders. "On genuine invariance learning without weight-tying". In: *Proceedings of 2nd Annual Workshop on Topology, Algebra, and Geometry in Machine Learning (TAG-ML)*. Vol. 221. PMLR, 2023, pp. 218–227.

[37] C. A. Shewmake, D. Buracas, H. Lillemark, J. Shin, E. J. **Bekkers**, N. Miolane, and B. Olshausen. "Visual Scene Representation with Hierarchical Equivariant Sparse Coding". In: *NeurIPS 2023 Workshop on Symmetry and Geometry in Neural Representations*. 2023.

[38] V. van Veldhuizen, S. Vadgama, O. de Boer, S. Meijer, and E. J. **Bekkers**. "Modeling Barrett's Esophagus Progression Using Geometric Variational Autoencoders". In: *Cancer Prevention Through Early Detection*. Ed. by S. Ali, F. van der Sommen, M. van Eijnatten, B. W. Papiez, Y. Jin, and I. Kolenbrander. Cham: Springer Nature Switzerland, 2023, pp. 132–142.

[39] R. Liu, F. Lauze, E. J. **Bekkers**, K. Erleben, and S. Darkner. "Group convolutional neural networks for DWI segmentation". In: *Geometric Deep Learning in Medical Image Analysis*. PMLR, 2022, pp. 96–106.

[40] S. Vadgama, J. M. Tomczak, and E. J. **Bekkers**. "Kendall Shape-VAE: Learning Shapes in a Generative Framework". In: *NeurIPS 2022 Workshop on Symmetry and Geometry in Neural Representations*. 2022.

[41] E. St Onge, S. Meesters, E. J. **Bekkers**, M. Descoteaux, and R. Duits. "HARDI denoising with mean-curvature enhancement PDE on SE (3)". In: *ISMRM Proceedings, Montreal*. 2019, pp. 1–3.

[42] B. Dashtbozorg, S. Abbasi-Sureshjani, J. Zhang, F. Huang, E. J. **Bekkers**, and B. M. ter Haar Romeny. "Infrastructure for Retinal Image Analysis". English. In: *Proceedings of the Ophthalmic Medical Image Analysis Third International Workshop, OMIA 2016, Held in Conjunction with MICCAI 2016, Athens, Greece, October 21, 2015*. Ed. by E. Trucco, X. Chen, M. Garvin, J. Liu, and X. Frank. Iowa Research Online, 2016, pp. 1–8.

[43] J. Zhang, E. J. **Bekkers**, S. Abbasi-Sureshjani, B. Dashtbozorg, and B. ter Haar Romeny. "Bridging Disconnected Curvilinear Structures via Numerical Evolutions of Completion Process in Ophthalmologic Images". In: *Proceedings of the Ophthalmic Medical Image Analysis International Workshop*. Vol. 3. Issue: 2016. University of Iowa, 2016.

[44] E. J. **Bekkers**, J. Zhang, R. Duits, and B. M. ter Haar Romeny. "Curvature Based Biomarkers for Diabetic Retinopathy via Exponential Curve Fits in SE(2)". English. In: *Proceedings of the Ophthalmic Medical Image Analysis Second International Workshop, OMIA 2015, Held in Conjunction with MICCAI 2015, Munchen, Germany,*

October 9, 2015. Ed. by E. Trucco, X. Chen, M. Garvin, J. Liu, and X. Frank. Iowa Research Online, 2015, pp. 113–120.

[45] K. A. J. Eppenhof, E. J. **Bekkers**, T. T. J. M. Berendschot, J. P. W. Pluim, and B. M. ter Haar Romeny. "Retinal Artery/Vein Classifcation via Graph Cut Optimization". English. In: *Proceedings of the Ophthalmic Medical Image Analysis Second International Workshop, OMIA 2015, Held in Conjunction with MICCAI 2015, Munchen, Germany, October 9, 2015.* Ed. by E. Trucco, X. Chen, M. Garvin, J. Liu, and X. Frank. Iowa Research Online, 2015, pp. 121–128.

[46] F. Huang, J. Zhang, E. J. **Bekkers**, B. Dashtbozorg, and B. M. ter Haar Romeny. "Stability Analysis of Fractal Dimension in Retinal Vasculature". English. In: *Proceedings of the Ophthalmic Medical Image Analysis Second International Workshop, OMIA 2015, Held in Conjunction with MICCAI 2015, Munchen, Germany, October 9, 2015.* Ed. by E. Trucco, X. Chen, M. Garvin, J. Liu, and X. Frank. Iowa Research Online, 2015, pp. 1–8.

EXTENDED ABSTRACTS

[47] D. M. Knigge, D. Wessels, R. Valperga, S. Papa, S. Gavves, and E. J. **Bekkers**. "Equivariant Neural Fields For Symmetry Preserving Continous PDE Forecasting". In: *ICLR 2024 Workshop on AI4DifferentialEquations In Science.* 2024.

[48] R. C. Klein, F. E. van Lieshout, M. Z. Kolk, K. van Geijtenbeek, R. Vos, S. Ruiperez-Campillo, R. Feng, B. Deb, P. Ganesan, R. Knops, I. Isgum, S. Narayan, E. J. **Bekkers**, B. de Vos, and F. V. Tjong. "Weakly-Supervised Deep Learning for Left Ventricle Fibrosis Segmentation in Cardiac MRI Using Image-Level Labels". In: *2022 Computing in Cardiology (CinC).* Vol. 498. ISSN: 2325-887X. Sept. 2022, pp. 1–4.

[49] D. W. Romero, D. M. Knigge, A. Gu, E. J. **Bekkers**, E. Gavves, J. M. Tomczak, and M. Hoogendoorn. "Towards a General Purpose CNN for Long Range Dependencies in ND". In: *Workshop on Continuous Time Methods for Machine Learning (ICML 2022).* arXiv preprint arXiv:2206.03398, 2022.

[50] F. E. Van Lieshout, R. C. Klein, M. Z. Kolk, K. Van Geijtenbeek, R. Vos, S. Ruiperez-Campillo, R. Feng, B. Deb, P. Ganesan, R. Knops, I. Isgum, S. Narayan, E. J. **Bekkers**, B. Vos, F. V. Tjong, and D. R. I. s. consortium. "Deep Learning for Ventricular Arrhythmia Prediction Using Fibrosis Segmentations on Cardiac MRI Data". In: *2022 Computing in Cardiology (CinC).* Vol. 498. ISSN: 2325-887X. Sept. 2022, pp. 1–4.

[51] M. B. Vessies, S. P. Vadgama, R. R. van de Leur, P. A. Doevendans, R. J. Hassink, E. J. **Bekkers**, and R. van Es. "Interpretable ECG classification via a query-based latent space traversal (qLST)". In: *Machine Learning for Health (ML4H) - Extended Abstract.* 2021.

[52] J. Zuiderveld, M. Federici, and E. J. **Bekkers**. "Towards Lightweight Controllable Audio Synthesis with Conditional Implicit Neural Representations". In: *NeurIPS 2021 Workshop on Deep Generative Models and Downstream Applications.* 2021.

JOURNAL PUBLICATIONS

[53] M. Botros, O. J. d. Boer, B. Cardenas, E. J. **Bekkers**, M. Jansen, M. J. v. d. Wel, C. I. Sánchez, and S. L. Meijer. "Deep Learning for Histopathological Assessment of Esophageal Adenocarcinoma Precursor Lesions". In: *Modern Pathology* 37.8 (2024), p. 100531.

[54] M. Z. Kolk, S. Ruipérez-Campillo, L. Alvarez-Florez, B. Deb, E. J. **Bekkers**, C. P. Allaart, A.-L. C. Van Der Lingen, P. Clopton, I. Išgum, A. A. Wilde, et al. "Dynamic prediction of malignant ventricular arrhythmias using neural networks in patients with an implantable cardioverter-defibrillator". In: *Ebiomedicine* 99 (2024). Publisher: Elsevier.

[55] D. F. Marzella, G. Crocioni, T. Radusinović, D. Lepikhov, H. Severin, D. L. Bodor, D. T. Rademaker, C. Lin, S. Georgievska, A. L. Kessler, P. Lopez-Tarifa, S. Buschow, E. J. **Bekkers**, and L. C. Xue. "Improving generalizability for MHC-binding peptide predictions through structure-based geometric deep learning". In: *Nature Computational Biology* (2024).

[56] D. W. Romero, E. J. **Bekkers**, J. M. Tomczak, and M. Hoogendoorn. "Wavelet Networks: Scale-Translation Equivariant Learning From Raw Time-Series". In: *Transactions on Machine Learning Research* (2024).

[57] M. Z. Kolk, S. Ruipérez-Campillo, B. Deb, E. J. **Bekkers**, C. P. Allaart, A. J. Rogers, A. Van Der Lingen, L. Alvarez Florez, I. Isgum, B. De Vos, et al. "Optimising Patient Selection for Primary Prevention ICD Implantation: Utilising Multimodal Machine Learning to Assess Risk of ICD Non-Benefit". In: *Europace* (2023). Publisher: Oxford University Press, euad271.

[58] M. Kolk, S. Ruiperez-Campillo, B. Deb, E. J. **Bekkers**, B. De Vos, A. Van Der Lingen, C. Allaart, I. Isgum, A. Rogers, P. Clopton, et al. "Improved patient selection for primary prevention ICD implantation by predicting ICD non-benefit using artificial intelligence". In: *Europace* 25.Supplement_1 (2023). Publisher: Oxford University Press US, euad122–537.

[59] B. Smets, J. Portegies, E. J. **Bekkers**, and R. Duits. "PDE-based group equivariant convolutional neural networks". In: *Journal of Mathematical Imaging and Vision* (2022). Publisher: Springer, pp. 1–31.

[60] R. Duits, B. Smets, A. Wemmenhove, J. Portegies, and E. J. **Bekkers**. "Recent Geometric Flows in Multi-orientation Image Processing via a Cartan Connection". In: *Handbook of Mathematical Models and Algorithms in Computer Vision and Imaging: Mathematical Imaging and Vision* (2021). Publisher: Springer, pp. 1–60.

[61] M. W. Lafarge, E. J. **Bekkers**, J. P. W. Pluim, R. Duits, and M. Veta. "Roto-translation equivariant convolutional networks: Application to histopathology image analysis". In: *Medical Image Analysis* 68 (2020). Publisher: Elsevier, p. 101849.

[62] R. Duits, E. J. **Bekkers**, and A. Mashtakov. "Fourier Transform on the Homogeneous Space of 3D Positions and Orientations for Exact Solutions to Linear PDEs". In: *Entropy* 21.1 (2019).

[63] E. J. **Bekkers**, D. Chen, and J. M. Portegies. "Nilpotent Approximations of Sub-Riemannian Distances for Fast Perceptual Grouping of Blood Vessels in 2D and 3D". In: *Journal of Mathematical Imaging and Vision* 60.6 (2018), pp. 882–899.

[64] E. J. **Bekkers**, M. Loog, B. M. ter Haar Romeny, and R. Duits. "Template matching via densities on the roto-translation group". In: *IEEE transactions on pattern analysis and machine intelligence* 40.2 (2018), pp. 452–466.

[65] M. M. H. J. Janssen, A. J. E. M. Janssen, E. J. **Bekkers**, J. Oliván Bescós, and R. Duits. "Design and Processing of Invertible Orientation Scores of 3D Images". In: *Journal of Mathematical Imaging and Vision* (2018), pp. 1–32.

[66] J. Zhang, E. J. **Bekkers**, D. Chen, T. T. J. M. Berendschot, J. Schouten, J. P. W. Pluim, Y. Shi, B. Dashtbozorg, and B. M. ter Haar Romeny. "Reconnection of Interrupted Curvilinear Structures via Cortically Inspired Completion for Ophthalmologic Images". In: *IEEE Transactions on Biomedical Engineering* 65.5 (2018), pp. 1151–1165.

[67] A. P. Mashtakov, R. Duits, Y. L. Sachkov, E. J. **Bekkers**, and I. Beschastnyi. "Tracking of Lines in Spherical Images via Sub-Riemannian Geodesics in SO(3)". In: *Journal of Mathematical Imaging and Vision* 58.2 (2017), pp. 239–264.

[68] J. Zhang, Y. Chen, E. J. **Bekkers**, M. Wang, B. Dashtbozorg, and B. M. ter Haar Romeny. "Retinal vessel delineation using a brain-inspired wavelet transform and random forest". In: *Pattern Recognition* 69 (2017), pp. 107–123.

[69] B. M. ter Haar Romeny, E. J. **Bekkers**, J. Zhang, S. Abbasi-Sureshjani, F. Huang, R. Duits, B. Dashtbozorg, T. T. J. M. Berendschot, I. Smit-Ockeloen, K. A. J. Eppenhof, et al. "Brain-inspired algorithms for retinal image analysis". In: *Machine Vision and Applications* (2016), pp. 1–19.

[70] F. Huang, B. Dashtbozorg, J. Zhang, E. J. **Bekkers**, S. Abbasi-Sureshjani, T. Chan, and B. M. ter Haar Romeny. "Reliability of Using Retinal Vascular Fractal Dimension as a Biomarker in the Diabetic Retinopathy Detection". In: *Journal of Ophthalmology* 2016 (2016).

[71] J. Zhang, B. Dashtbozorg, E. J. **Bekkers**, J. P. W. Pluim, R. Duits, and B. M. ter Haar Romeny. "Robust Retinal Vessel Segmentation via Locally Adaptive Derivative

Frames in Orientation Scores". In: *IEEE Transactions on Medical Imaging* PP.99 (2016), pp. 1–1.

[72] E. J. **Bekkers**, R. Duits, A. P. Mashtakov, and G. R. Sanguinetti. "A PDE Approach to Data-Driven Sub-Riemannian Geodesics in SE(2)". In: *SIAM Journal on Imaging Sciences* 8.4 (2015), pp. 2740–2770.

[73] E. J. **Bekkers**, R. Duits, T. T. J. M. Berendschot, and B. M. ter Haar Romeny. "A Multi-Orientation Analysis Approach to Retinal Vessel Tracking". English. In: *Journal of Mathematical Imaging and Vision* 49.3 (2014), pp. 583–610.

PREPRINTS

[74] A. Draganov, S. Vadgama, and E. J. **Bekkers**. "The Hidden Pitfalls of the Cosine Similarity Loss". In: *arXiv preprint arXiv:2406.16468* (2024).

[75] D. M. Knigge, D. R. Wessels, R. Valperga, S. Papa, J.-J. Sonke, E. Gavves, and E. J. **Bekkers**. "Space-Time Continuous PDE Forecasting using Equivariant Neural Fields". In: *arXiv preprint arXiv:2406.06660* (2024).

[76] D. R. Wessels, D. M. Knigge, S. Papa, R. Valperga, S. Vadgama, E. Gavves, and E. J. **Bekkers**. "Grounding Continuous Representations in Geometry: Equivariant Neural Fields". In: *arXiv preprint arXiv:2406.05753* (2024).

[77] X. Zhang, L. Wang, J. Helwig, Y. Luo, C. Fu, Y. Xie, M. Liu, Y. Lin, Z. Xu, K. Yan, et al. "Artificial intelligence for science in quantum, atomistic, and continuum systems". In: *arXiv preprint arXiv:2307.08423* (2023).

[78] H. Aguettaz, E. J. **Bekkers**, and M. Defferrard. "ChebLieNet: Invariant spectral graph NNs turned equivariant by Riemannian geometry on Lie groups". In: *arXiv preprint arXiv:2111.12139* (2021).