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Christoph Gerhardt

Dr.-Ing. Candidate ▪ Computer Vision & Deep Learning Google Scholar | Web of Science

Research Profile

Keywords: Computer Vision ▪ Semantic Segmentation ▪ 360° Image Processing ▪ Weather Robustness ▪ Data Augmentation ▪ Neural Network Architectures ▪ Outdoor Scene Understanding ▪ Object Detection

Education

Oct 2019 – May 2026 (expected) **Dr.-Ing. (PhD) in Computer Science**, *Technische Universität Ilmenau*, Germany
- *Dissertation:* "Comprehensive Outdoor Scene Understanding Through Multi-Scale Neural Networks: From 360° Object Detection to Panoramic Segmentation and Weather-Robust Augmentation"
- *Supervisor:* Prof. Dr. rer. nat. Wolfgang Broll
- *Reviewers:* Prof. Dr. rer. nat. W. Broll (TU Ilmenau), Prof. Dr.-Ing. P. Mäder (TU Ilmenau), Prof. Dr. N. Jacobs (Washington Univ. in St. Louis)
- *Research Group:* Virtual Worlds and Digital Games (VWDG)
- *Funding:* Free State of Thuringia (Grant No. 2017 FE 9147), co-financed by the ERDF

Oct 2014 – Sep 2017 **M.Sc. Computer Engineering (*Ingenieurinformatik*)**, *Technische Universität Ilmenau*, Germany, *Final Grade: 1.5 (very good)*
- Specialisation: Multimedia Information and Communication Systems
- *Thesis:* "Selektive Verschlüsselung von Gesichtern in Videodaten unter Verwendung des H.264-Standards"
- Courses in image processing, pattern recognition, media security, signal processing

Oct 2010 – Sep 2014 **B.Sc. Computer Engineering (*Ingenieurinformatik*)**, *Technische Universität Ilmenau*, Germany, *Final Grade: 1.8 (good)*
- *Thesis:* "Entwicklung eines Verfahrens zur Verbesserung von Mikrofonklassifizierung basierend auf der Analyse von Umwelteinflüssen"
- Foundation in algorithms, software engineering, mathematics, electronics

Jun 2009 **Abitur**, *Gymnasium "Am Lindenberg"*, Ilmenau, Germany, *Grade: 1.5*

Professional Experience

Feb 2019 – present **Research Associate (*Wissenschaftlicher Mitarbeiter*)**, *Technische Universität Ilmenau*, Ilmenau, Germany

Fachgebiet Virtuelle Welten und Digitale Spiele (Prof. Dr. W. Broll)
- Designed and evaluated multi-scale neural network architectures for semantic segmentation of universal outdoor scenes (OUTSIDE, SkyCloud, SkyCloud360)
- Developed the **AWARE** benchmark framework with three pipelines (SWIFT, PRISM, PROVE) for systematic evaluation of 25 weather augmentation strategies
- Created and publicly released five research datasets totalling 89 000+ annotated images
- Adapted object detection networks for traffic sign recognition in equirectangular 360° imagery; integration with NOVASIB GmbH's TT-SIB INFOSYS® road inventory system
- Co-supervised 4+ Bachelor's and Master's theses in computer vision and VR/AR
- Teaching assistant for courses: *Virtual and Augmented Reality*, *Virtuelle Welten*, and computer vision seminars
- Contributed to collaborative research on avatar realism, AR communication, and gaze behaviour (10 co-authored publications at IEEE VR, ACM CSCW, ACM ETRA, IEEE TVCG)

Feb 2017 – Jan 2019 **Software Developer**, *Fraunhofer Institute for Digital Media Technology (IDMT)*, Ilmenau, Germany

Group: Virtual Acoustics

- Developed C++ and Python components for real-time spatial audio rendering engines
- Implemented signal processing algorithms for binaural reproduction and room simulation
- Contributed to cross-platform software used in industrial and research applications

Jul 2016 – Jan 2017 **Student Research Assistant (*Hilfswiss. Mitarbeiter*)**, *Fraunhofer IDMT*, Ilmenau, Germany

Group: Media Distribution and Security

- Research and implementation of face detection and region-of-interest encryption in H.264/AVC video streams
- Work contributed to IEEE VCIP 2017 publication on selective face encryption

Internships

Sep 2013 – Jan 2014 **Research Intern**, *Fraunhofer IDMT*, Ilmenau, Germany

Group: Media Distribution and Security — Developed prototypes for multimedia content protection and forensic watermarking.

Mar 2013 **Engineering Intern**, *SIOS Meßtechnik GmbH*, Ilmenau, Germany

Precision measurement technology — Exposure to industrial laser interferometry and metrology.

Sep – Oct 2012 **Engineering Intern**, *GPM Anlagenbau und Industrieanlagen GmbH*, Mainz, Germany

Plant engineering — Practical experience in industrial automation and process control.

Civic Service

Jul 2009 – Jun 2010 **Voluntary Military Service (*Freiwilliger Wehrdienst*)**, *Führungsunterstützungsbataillon 292*, Dillingen a. d. Donau, Germany

Command support and signal communications; leadership training.

Publications

15 total | 5 first-author

First Author — Dissertation-Related ⋆

[1] **C. Gerhardt** and W. Broll, "SkyCloud360: Sky and Cloud Segmentation in Equirectangular Images," in *Proc. 10th Int. Conf. Image, Vision and Computing (ICIVC)*, Chengdu, China, 2025, pp. 48–58. doi:10.1109/ICIVC66358.2025.11200399.

[2] **C. Gerhardt**, F. Weidner, and W. Broll, "SkyCloud: Neural Network-Based Sky and Cloud Segmentation from Natural Images," in *Proc. 8th Int. Conf. Image, Vision and Computing (ICIVC)*, Dalian, China, 2023. doi:10.1109/ICIVC58118.2023.10270450.

[3] **C. Gerhardt**, F. Weidner, and W. Broll, "OUTSIDE: Multi-Scale Semantic Segmentation of Universal Outdoor Scenes," in *Proc. IEEE 23rd Int. Workshop Multimedia Signal Processing (MMSP)*, Tampere, Finland, 2021, pp. 1–6. doi:10.1109/MMSP53017.2021.9733652.

[4] **C. Gerhardt** and W. Broll, "Neural Network-Based Traffic Sign Recognition in 360° Images for Semi-Automatic Road Maintenance Inventory," in *Proc. IEEE 23rd Int. Conf. Intelligent Transportation Systems (ITSC)*, 2020, art. no. 9294610. doi:10.1109/ITSC45102.2020.9294610.

[5] **C. Gerhardt**, M. M. Salman, and W. Broll, "AWARE: Augmentation for Weather-Adverse Robustness Evaluation — Benchmarking Strategies for Improved Semantic Segmentation under Challenging Outdoor Conditions," *IEEE Access*, 2025 *(under review)*.

Co-Authored

[6] S. Arévalo Arboleda, J. Hartbrich, F. Weidner, S. B. Fischedick, **C. Gerhardt**, K. Richter, C. Kunert, B. Vorhof, H.-M. Groß, W. Broll, and A. Raake, "Robot, Avatar, or Human: The Impact of Partner Representation and Task on the Communication Experience," *Proc. ACM Hum.-Comput. Interact.*, vol. 9, no. CSCW, art. CSCW472, 2025. doi:10.1145/3757653.

[7] E. Makled, **C. Gerhardt**, T. Schwandt, F. Weidner, and W. Broll, "Evaluating Behavioral Realism in AR and VR: A Comparison of Single-Point IK and Full-Body Motion Capture Virtual Humans," *The Visual Computer*, vol. 41, no. 14, pp. 11721–11733, 2025. doi:10.1007/s00371-025-03934-5.

[8] V. Mikhailova, C. Kunert, J. Hartbrich, T. Schwandt, **C. Gerhardt**, A. Raake, W. Broll, and N. Döring, "Address-

ing the Avatar in the Room: A User Study on Older Adults' Experiences with a Wearable Augmented Reality Communication System," in *Human Aspects of IT for the Aged Population (ITAP/HCII 2025)*, LNCS 15809, Springer, 2025. doi:10.1007/978-3-031-92707-2_21.

[9] V. Mikhailova, C. Kunert, J. Hartbrich, T. Schwandt, **C. Gerhardt**, A. Raake, W. Broll, and N. Döring, "Work-in-Progress: Older Adults' Experiences with an Augmented Reality Communication System," in *Proc. ACM Int. Conf. Interactive Media Experiences (IMX)*, Stockholm, Sweden, 2024. doi:10.1145/3639701.3663641.

[10] E. Makled, **C. Gerhardt**, T. Schwandt, F. Weidner, and W. Broll, "Investigating Behavioral Realism of Single-Point IK Animated Avatars of Others in AR and VR," in *Proc. Int. Conf. Cyberworlds (CW)*, Kofu, Japan, 2024, pp. 1–8. doi:10.1109/CW64301.2024.00010.

[11] F. Weidner, J. Hartbrich, S. Arévalo Arboleda, C. Kunert, C. Schneiderwind, C. Diao, **C. Gerhardt**, T. Surdu, W. Broll, S. Werner, and A. Raake, "Eyes on the Narrative: Exploring the Impact of Visual Realism and Audio Presentation on Gaze Behavior in AR Storytelling," in *Proc. ACM Symp. Eye Tracking Research & Applications (ETRA)*, Glasgow, UK, 2024. doi:10.1145/3649902.3653344.

[12] V. Mikhailova, **C. Gerhardt**, C. Kunert, T. Schwandt, F. Weidner, W. Broll, and N. Döring, "Age and Realism of Avatars in Simulated Augmented Reality: Experimental Evaluation of Anticipated User Experience," in *Proc. IEEE Conf. Virtual Reality and 3D User Interfaces (VR)*, Orlando, FL, 2024, pp. 83–93. doi:10.1109/VR58804.2024.00032.

[13] S. Arévalo Arboleda, C. Kunert, J. Hartbrich, C. Schneiderwind, C. Diao, **C. Gerhardt**, T. Surdu, F. Weidner, W. Broll, S. Werner, and A. Raake, "Beyond Looks: A Study on Agent Movement and Audiovisual Spatial Coherence in Augmented Reality," in *Proc. IEEE Conf. Virtual Reality and 3D User Interfaces (VR)*, Orlando, FL, 2024, pp. 502–512. doi:10.1109/VR58804.2024.00071.

[14] F. Weidner, G. Böttcher, S. Arévalo Arboleda, C. Diao, L. Sinani, C. Kunert, **C. Gerhardt**, W. Broll, and A. Raake, "A Systematic Review on the Visualization of Avatars and Agents in AR & VR Displayed Using Head-Mounted Displays," *IEEE Trans. Vis. Comput. Graphics*, vol. 29, no. 5, pp. 2596–2606, 2023. doi:10.1109/TVCG.2023.3247072.

[15] **C. Gerhardt**, P. Aichroth, and S. Mann, "Selective Face Encryption in H.264 Encoded Videos," in *Proc. IEEE Visual Communications and Image Processing (VCIP)*, 2017, pp. 1–4. doi:10.1109/VCIP.2017.8305040.

Open-Source Projects & Datasets

AWARE Comprehensive weather-augmentation benchmark framework for semantic segmentation robustness. Three modular pipelines: **SWIFT** (classical augmentation), **PRISM** (generative synthesis), and **PROVE** (evaluation). Benchmarks 25 augmentation strategies across 7 weather categories on Cityscapes.
https://carhartt21.github.io/AWARE carhartt21/SWIFT carhartt21/PRISM carhartt21/PROVE

AWACS Weather-balanced Augmented Cityscapes dataset — **71 400 images** generated from Cityscapes val/test splits using 25 diverse augmentation strategies. Includes pixel-accurate segmentation labels and augmentation metadata.

SkyCloud360 **600** equirectangular panoramic images with pixel-level sky/cloud annotations. Paired with a segmentation pipeline addressing projection-induced distortions.
carhartt21/SkyCloud360 https://osf.io/a5ews

SkyCloudNet Sky and cloud segmentation network for standard perspective images, with pre-trained weights.
carhartt21/SkyCloudNet https://osf.io/y69ah https://osf.io/duvkq (models)

OUTSIDE15k Universal outdoor scene dataset: **15 000 images** annotated across **24 semantic classes**.
carhartt21/outsideNet

360° Detection Traffic sign dataset: **2 500 panoramic images** with bounding boxes for **81 sign classes**. Deployed in NOVASIB GmbH's road inventory workflow.
carhartt21/360-Object-Detection https://osf.io/fsteu

Technical Skills

Programming	Python ▪ C/C++/C# ▪ Java ▪ MATLAB/Octave ▪ SQL ▪ Bash ▪ LaTeX
ML & DL	PyTorch ▪ TensorFlow/Keras ▪ scikit-learn ▪ OpenCV ▪ ONNX ▪ Albumentations ▪ timm
Infrastructure	Git ▪ Docker ▪ Linux (Ubuntu/CentOS) ▪ Slurm HPC ▪ Weights & Biases ▪ Jupyter ▪ CI/CD
Domains	Semantic Segmentation ▪ Object Detection ▪ Data Augmentation ▪ 360° Vision ▪ VR/AR ▪ Audio Processing

Languages

German	Native speaker	
English	Fluent (C1+)	*academic writing, conference presentations*
French	Basic knowledge (A2)	
Serbian	Basic knowledge (A2)	

Certifications & Licenses

2023 **C-Lizenz (Coaching License)**
DFB football coaching certification.

2023 **EU Remote Pilot Certificate (A1/A3)**
Drone operation in open category per EU Regulation 2019/947.

Academic Service & Teaching

Teaching

- Teaching assistant: *Virtual and Augmented Reality* (WS 2019–2025, SS 2026)
- Teaching assistant: *Virtuelle Welten* (SS 2020–2025)
- Teaching assistant: *Game Development* (WS 2025/26)
- Seminar supervision in computer vision and deep learning

Thesis Sup.

- Zamam Mirza: "Synthetic Data Generation for Semantic Segmentation and Object Detection Using Generative Models"
- Syed Ajaz Zaidi: "Enhancing Digital Reading with Gaze-Triggered Audio Cues and Audiobook Listening with Augmented Sound Effects"

Projects Supervision of 16+ student research projects (SS 2024 – SS 2026) in generative models, data augmentation, 3D avatars, quality assessment, and XR

Reviewing

- Journals: IEEE TVCG, IEEE Access, IEEE Open J. Signal Processing
- Conferences: IEEE ISMAR 2024, IEEE ISMAR 2025

Funding

2019 – 2024 **Free State of Thuringia** — Grant No. 2017 FE 9147, co-financed by the European Union under the European Regional Development Fund (ERDF). Project focus: intelligent road infrastructure analysis using neural networks and 360° imagery.

Ilmenau, March 16, 2026