Research Group Leader (Wearable Systems) Karlsruhe Institute of Technology

Education

11/2019-07/2023	PhD (summa cum laude), Karlsruhe Institute of Technology , Germany Computer Science (Dr. Ing.), " <i>Earables: Wearable Computing on the Ears</i> ". Advisor: Prof. Dr. Michael Beigl. Secondary Advisor: Prof. Dr. Hans Gellersen.
10/2013-10/2019	B.Sc. & M.Sc. in Computer Science, Karlsruhe Institute of Technology , Germany Specialization: Cognitive Systems (AI), Telematics. Minor: Finance and Economics. Thesis: " <i>Wearability and Design of a Fully-Integrated Sleep Tracker</i> ".
2006-2013	Part-Time Student, Hector Seminar , Germany Highly selective study program (by Dr. H.W. & J. Hector, co-founder SAP).
	Professional Experience
10/2023-now	Research Group Leader, Karlsruhe Institute of Technology , Germany <i>Wearable Systems</i> within TECO at the Faculty of Computer Science.
03/2023-now	Founder, TOBI Technologies , Germany Spinoff dedicated to commercializing embedded wearable research (OpenEarable).
08/2022-11/2022	Visiting Researcher, Massachusetts Institute of Technology , Cambridge, USA Space Exploration Initiative at Responsive Environments (Prof. Dr. Joseph Paradiso).
11/2019-09/2023	Research and Teaching Assistant, Karlsruhe Institute of Technology , Germany TECO (Prof. Dr. Michael Beigl) at the Faculty of Computer Science.
04/2017-09/2017	Visiting Researcher, Lancaster University, Lancaster, United Kingdom Interactive Systems (Prof. Dr. Hans Gellersen) in the Department of Computer Science.
10/2017-10/2020	Freelancer, Various Projects , Karlsruhe, Germany Development of various websites e.g. coronazähler.de (> 5 million users).
10/2016-12/2016	Intern, Microsoft , Prague, Czech Republic Identity and Authentication Team of Skype.
10/2014-10/2017	Founder, enCourage Labs, Karlsruhe, Germany Development agency for different cross-platform smartphone apps.
	Honors and Awards
2024	Helmholtz Dissertation Award 2023, research track "Information", awarded across all Helmholtz research units in Germany
2023	Blanc & Fischer Dissertation Innovation Award, across all university departments

	Special Recognition for Outstanding Review , ACM Conference on Human Factors in Computing Systems (CHI)
2022	Special Recognition for Outstanding Review , Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies
2021	Special Recognition for Outstanding Review , Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies
2020	Best Paper Award ACM International Symposium on Wearable Computer
	Best Master Thesis Award in Computer Science (sponsored by SICK)
	Special Recognition for Outstanding Review , Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies
2019	Best Paper Award, Earcomp 2019
	Audience Award, HackZurich (Europe's largest Hackathon, 360 participants)
2018	1st Prize, Deeptech: AI Hackathon (70 participants)
	1st Prize, OpenCodes Hackathon (150 participants)
2017	1st Prize, InsurHack Hackathon (130 participants)
	1st Prize + Audience Award, Coding Chemistry Hackathon (XXX participants)
2016	1st Prize, Accenture DigiHack Prague (400 participants in parallel in 8 countries)
	1st Prize, code_n Hackathon (50 participants)
	1st Prize, Xamarin Evolve Mini Hacks in Orlando (USA)
2015	1st Prize, Microsoft Imagine Cup Germany, world finalist in Redmond (USA)
	1st Prize, XHack Karlsruhe
2009	1st Prize, Jugend forscht (Schüler experimentieren), Rhein-Neckar Area Germany
	External Funding Total funding awarded 681,000€ (as sole lead on proposal development and execution).
	technology exploration of ear-based sensing for health applications, 120,000€

embedded ML + wearables incl. large three months data campaign, 175,000€

embedded machine learning with audio signals, 60,000€

	embedded machine learning tutorials, 21,000€	
	custom wearable and embedded machine learning, 22,000€	
	SoftwareCampus , German Ministry of Education and Research <i>Fit2Ear: Personalized AI-generated Otoplastic</i> , 97,000€	
	BMBF Project Grant , German Ministry of Education and Research, StartMTI <i>Aura: Diagnosing Sleep Apnea Using a Wearable Patch</i> , 180,000€	
	Scholarships	
03/2024	CITRIS Health Innovation Intensive, health innovation program funded by the German Government at UC Berkeley, UC Santa Cruz, UC Merced, and UC Davis	
09/2022-11/2022	KIT Research Travel Grant, research visit at MIT DAAD IFI International Research Stays for CS , resigned (conflicting grants)	
	Invited Talks	
Invited Talks	 Karlsruhe Institute of Technology, Germany. Host: Dr. Niels Feldmann. 02/2024. Bosch Sensortec GmbH, Stuttgart, Germany. Host: Aibin Lazar. 01/2024. Karlsruhe Institute of Technology, Germany. Host: Dr. Jürgen Spitzer. 11/2023. Biosignals Connect, Karlsruhe, Germany. Host: Dr. Michael Knierim. 08/2023. MIT Media Lab, Cambridge, USA. Host: Prof. Dr. Joseph Paradiso. 11/2022. MIT Media Lab, Cambridge, USA. Host: Prof. Dr. Joseph Paradiso. 04/2022. Bosch Sensortec GmbH, Stuttgart, Germany. Host: PD Dr. Victor Pankratius. 07/2021. BASF SE, Ludwigshafen, Germany, Host: Dr. Martin Brudermüller (CEO), 02/2018. 	
	Teaching Experience	
Winter 2023/24	 Mobile Computing & Internet of Things Exercise (2.5 ECTS), ≈ 60 students teaching quality index of "100%" (perfect score) arranged guest talks by Bosch Sensortec and Amazon Web Services 	
Summer 2023	Software Engineering in Practice (9 ECTS), 10 students	
Winter 2022/23	Mobile Computing & Internet of Things Exercise (in 5 ECTS lecture), ≈ 60 students	
Winter 2021/22	Mobile Computing & Internet of Things Exercise (in 5 ECTS lecture), ≈ 60 students Mobile Computing Proseminar (3 ECTS), 1 student	
Summer 2021	Designing and Conducting Experimental Studies (4 ECTS), 4 students Mobile Computing Proseminar (3 ECTS), 1 student	
Winter 2020/21	Mobile Computing & Internet of Things Exercise (in 5 ECTS lecture), ≈ 60 students	

	 Software Engineering in Practice (9 ECTS), 10 students Designing & Conducting Experimental Studies Seminar (4 ECTS), 3 students Mobile Computing Proseminar (3 ECTS), 1 student Software Engineering in Practice (9 ECTS), 10 students Interactive Analytics Seminar (4 ECTS), 4 students Ubiquitous Computing and Mobile Computing Seminar (3 ECTS), 1 student Software Engineering in Practice (9 ECTS), 20 students Mobile Computing Proseminar (3 ECTS), 1 student 		
Summer 2020			
Winter 2019/20			
	Research Group		
PhDs	Tobias King	08/2023-now	
	Jueun Lee	10/2023-now	
	Sarah Makarem	10/2023-now	
Student Research	Felix Schmitt	11/2023-now	
Assistants	Lukas Probst	06/2023-now	
	Dennis Moschina	01/2023-now	
	Oliver Bagge	01/2023-now	
	Nils Kerwer	01/2023-06/2023	
	Mark Schenkel	07/2022-12/2023	
	Vladimir Bashkuev	02/2022-04/2023	
	Ömer Yăgmurlu	01/2022-12/2023	
	Anja Hansen	11/2021-05/2022	
	Murat Kurnaz,	11/2021-12/2023	
	Philipp Lepold,	02/2021-now	
	Dylan Ray Roodt	01/2021-now	
	Michael Küttner	11/2019-now	
	Jennifer Münk	11/2019-11/2020	
	Daniel Wolffram	11/2019-09/2020	

Master and Bachelor Theses

I have supervised **7** master theses (30 ECTS) [M], **14** bachelor theses (15 ECTS) [B], and **2** research in practice projects (24 ECTS) [R].

2024	[M]	Anja Hansen, "BodyPursuit Interaction: Synchronizing Gaze with Body Motion"
	[M]	Philipp Lepold, "Open-Source Hardware for Biopotential Sensing with OpenEarable"
	[R]	Richard Sirius Hanser, "EarCapAuth: Capacitive Ear-Shape Sensing for Earable User Authentication"
	[B]	Dennis Moschina, "Coupling Heart Rate with Vibrotactile Cues to Induce Sleep"
2023	[M]	David Laubenstein, "Ear-Based Temperature Probing: Sensor Placement and Fusion for Wearable Applications"
	[B]	Tianchen Wang, "Gaze-Based Smooth Pursuit Gesture Interaction based on Hand Gestures"
	[M]	Julian Westermann (co-supervised with Dr. Peter Zeile), "Low-Cost Lidar-Based Overtaking Detection for Bicycles"
2022	[M]	Tobias King (co-supervised with Yexu Zhou), "Hardware-Aware Neural Architecture Search for Time Series Classification"
	[B]	Kathrin Blum, "Eye Tracking with Around-the-Ear Electrodes"
	[B]	Leonardo Weng, "Cardiopulmonary Resuscitation Support with a Earable Real Time Feedback System"
	[B]	Jan Ettrich, "Benchmarking Tool for Embedded Feature Extraction"
2021	[R]	Stefan Herrmann, "Cardiopulmonary Resuscitation Support: Comparison of Wrist-, Chest-, and Ear-Worn Devices and Estimation Algorithms"
	[B]	Pierre Brosemer, "Real-Time Matching of Video-Extracted Skeleton Data with Motion Data from Wearable Devices"
	[B]	Anja Hansen, "Matching Video-Extracted Motion Skeleton Data with Acceleration Data from Wearable Devices"
	[B]	Erwin Müller, "Predicting the Relative Head Yaw Angle from Earable Audio Features"
	[B]	Stefan Hermann (co-supervised with Paula Breitling), "Using Wearables to Improve Quality of Cardiopulmonary Resuscitation"
2020	[B]	Dennis Osipov, "Stress Prediction in Urban Traffic Using Wrist-Measured Bio Signals and Smartphone Sensors"
	[B]	Julian Westermann (co-supervised with Dr. Peter Zeile), "The Influence of Traffic and Vibrations on the Stress Experienced by eScooter Drivers"
	[B]	Victoria Karl, "Real-Time Stroke Sensing for Rowboats"

[B]	Michael Küttner, "Development and Evaluation of a Compression Algorithm for Periodic Medical Sensor Data"
[B]	David Laubenstein, "Classification of Respiratory Events with Earables and Machine Learning"
[M]	Jennifer Muenk (co-supervised with Paula Breitling), "Predictive Wound Documentation"
[M]	Christian Dinse, "Design and Validation of an Ear-Worn System for Detecting Apnea Events"
	Voluntary Service
Organizer	Local Chair, Mensch und Computer 2024 Technology Chair, Ubicomp 2021
Program Committee	IEEE International Conference on Activity and Behavior Computing (ABC) 2024
External reviewer	Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies (IMWUT) 02/2024, 11/2023, 08/2023, 02/2023, 11/2022, 05/2022, 02/2022, 11/2021, 08/2021, 05/2021, 02/2021, 11/2020, 08/2020, 05/2020
	ACM CHI Conference on Human Factors in Computing Systems (CHI) 2023, 2022, 2020
	ACM International Symposium on Wearable Computers (ISWC) 2023, 2022, 2021, 2020
	ACM Symposium on User Interface Software and Technology (UIST) 2023
	ACM MobileHCI 2024
	IEEE Computer 02/2024, 03/2023, 07/2022, 02/2022, 05/2020
	Taylor & Francis Ergonomics 04/2021
	Open Source and Other Projects
[OpenEarable]	openearable.com, MIT License, $218 \star$ (GitHub) World's first open-source ear-based sensing development platform.
[edge-ml]	edge-ml.org, MIT License, <u>34★ (GitHub)</u> End-to-end, browser-based machine learning framework for microcontrollers.

[GazeHeatmap]	github.com/TobiasRoeddiger/GazePointHeatMap, MIT License, <u>118★ (GitHub)</u> Command line tool to generate heatmap plots from gaze data.
[coronazähler]	coronazaehler.de, <u>5+ million unique visitors</u> , <u>100+ million sessions</u> First website in Germany to scrape COVID cases automatically from public sources.
[enCourage]	encourage-now.com, <u>5k+ downloads</u> App to send distress calls in case of emergency. Idea integrated in all iPhones today.
[AstroAnt]	media.mit.edu/projects/astroant-1/overview/, miniature lunar swarm robot Tiny robot with magnetic wheels that will measure the surface temperature of the MAPP-1 rover on the moon.

ACM IMWUT

ACM CHI

ACM ISWC, ACM AHs

Summary of Academic Achievements

24 publications including:



All citations and publications were achieved in 4 years. My research has received 2 best paper awards, 2 dissertation awards, and 1 Master thesis award.

My publications have appeared at various top venues in different communities with competitive acceptance rates of 20-30%. Out of all publications, 7 papers were published in A or A* venues (according to conferenceranks.com). The research communities I publish in include:

- Ubiguitous Computing
- Wearable Computing
- Human-Computer Interaction

Five Selected Papers

T. Röddiger, C. Clarke, P. Breitling, T. Schneegans, H. Zhao, H. Gellersen, and M. Beigl. "Sensing with Earables: A Systematic Literature Review and Taxonomy of Phenomena". Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies, 6 (3):1–57, 2022.

T. Röddiger, C. Clarke, D. Wolffram, M. Budde, and M. Beigl. "EarRumble: Discreet Hands-and Eyes-Free Input by Voluntary Tensor Tympani Muscle Contraction" In Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems. Yokohama, Japan, May 2021.

T. Röddiger, T. King, D. R. Roodt, C. Clarke, and M. Beigl. "OpenEarable: Open Hardware Earable Sensing Platform". In Adjunct Proceedings of the 2022 ACM International Joint Conference on Pervasive and Ubiquitous Computing and the 2022 ACM International Symposium on Wearable Computers). Online, Virtual, October 2022.

T. Röddiger, D. Wolffram, D. Laubenstein, M. Budde, and M. Beigl. "Towards Respiration Rate Monitoring Using an In-Ear Headphone Inertial Measurement Unit". In Proceedings of the 1st International Workshop on Earable Computing, EarComp'19, page 48-53. Association for Computing Machinery, 2019. Best Paper Award.

S. Hermann, P. Breitling, T. Röddiger, and M. Beigl. "Cardiopulmonary Resuscitation Support: Comparison of Wrist-, Chest-, and Ear-Worn Devices and Estimation Algorithms". In 2021 International Symposium on Wearable Computers. Online, Virtual, September 2021.

Peer-Reviewed Conference Papers

- [C8] M. T. Knierim, D. Puhl, G. Ivucic, and T. Röddiger. "OpenBCI + 3D-Printed Headphones = Open ExG Headphones – An Open-Source Research Platform for Biopotential Earable Applications". Late Breaking Work of the 2023 CHI Conference on Human Factors in Computing Systems. Hamburg, Germany, April 2023.
- [C7] T. Röddiger, C. Clarke, D. Wolffram, M. Budde, and M. Beigl. "EarRumble: Discreet Hands-and Eyes-Free Input by Voluntary Tensor Tympani Muscle Contraction" In Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems. Yokohama, Japan, May 2021.
- [C6] S. Hermann, P. Breitling, T. Röddiger, and M. Beigl. "Cardiopulmonary Resuscitation Support: Comparison of Wrist-, Chest-, and Ear-Worn Devices and Estimation Algorithms". In 2021 International Symposium on Wearable Computers. Online, Virtual, September 2021.
- [C5] E. Pescara, A. Stubenbord, T. Röddiger, L. Fang, and M. Beigl. "Where Should I look? Comparing Reference Frames for Spatial Tactile Cues". 2021 International Symposium on Wearable Computers. Online, Virtual, September 2021.
- [C4] T. Röddiger, M. Beigl, M. Hefenbrock, D. Wolffram, and E. Pescara. "Detecting Episodes of Increased Cough Using Kinetic Earables". In Augmented Humans Conference 2021. Virtual, Online, February 2021.
- [C3] L. Fang, T. Röddiger, H. Sun, N. Willenbacher, and M. Beigl. "FLECTILE: 3D-Printable Soft Actuators for Wearable Computing". In Proceedings of the 2020 ACM International Symposium on Wearable Computers. Online, Virtual, Sept. 2020. Best Paper Award.
- [C2] T. Röddiger, M. Beigl, and A. Exler. "Design Space and Usability of Earable Prototyping". In Proceedings of the 2020 International Symposium on Wearable Computers, pages 73–78, 2020.
- [C1] T. Röddiger, M. Beigl, D. Wolffram, M. Budde, and H. Sun. "PDMSkin: On-Skin Gestures with Printable Ultra-Stretchable Soft Electronic Second Skin". In Proceedings of the Augmented Humans International Conference, Online, Virtual, March 2020.

Peer-Reviewed Journal Papers

- [J2] T. Röddiger, C. Clarke, P. Breitling, T. Schneegans, H. Zhao, H. Gellersen, and M. Beigl. "Sensing with Earables: A Systematic Literature Review and Taxonomy of Phenomena". Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies, 6 (3):1–57, 2022.
- [J1] **T. Röddiger,** M. Beigl, D. Dörner, and M. Budde. "Responsible, Automated Data Gathering for Timely Citizen Dashboard Provision During a Global Pandemic (COVID-19)". Digital Government: Research and Practice, 2(1):1–9, 2020.

Peer-Reviewed Workshop Papers

[W4] D. Moschina, T. Röddiger, and M. Beigl. "Vertical Jump Test Using an Earable Accelerometer". In Adjunct Proceedings of the 2023 ACM International Joint Conference on Pervasive and Ubiquitous Computing & the 2023 ACM International Symposium on Wearable Computing. Cancun, Mexico, October 2023.

- [W3] T. Röddiger, T. King, D. R. Roodt, C. Clarke, and M. Beigl. "OpenEarable: Open Hardware Earable Sensing Platform". In Adjunct Proceedings of the 2022 ACM International Joint Conference on Pervasive and Ubiquitous Computing and the 2022 ACM International Symposium on Wearable Computers). Online, Virtual, October 2022.
- [W2] H. Zhao, T. Röddiger, and M. Beigl. "AirCase: Earable Charging Case with Air Quality Monitoring and Soundscape Sonification". In Adjunct Proceedings of the 2021 ACM International Joint Conference on Pervasive and Ubiquitous Computing. Online, Virtual, October 2021.
- [W1] T. Röddiger, D. Wolffram, D. Laubenstein, M. Budde, and M. Beigl. "Towards Respiration Rate Monitoring Using an In-Ear Headphone Inertial Measurement Unit". In Proceedings of the 1st International Workshop on Earable Computing, EarComp'19, page 48–53. Association for Computing Machinery, 2019. Best Paper Award.

Theses

- [T2] T. Röddiger, "Earables: Wearable Computing on the Ears". Karlsruhe Institute of Technology, Karlsruhe, Germany, July 2023. Blanc & Fischer Innovation Award 2023.
- [T1] T. Röddiger, "Exploring the Wearability and Design of a Full-Integrated Sleep Tracker". Karlsruhe Institute of Technology, Karlsruhe, Germany, October 2019.
 SICK Best Master Thesis in CS 2019 Award.

Lightly Reviewed Posters and Demos

- [D4] S. Hermann, T. Röddiger, and M. Beigl. "Towards Detecting Complete Chest Recoil from Smartphone Vibration Strength during Cardiopulmonary Resuscitation". In Proceedings of the 2022 ACM International Symposium on Wearable Computers. Online, Virtual, 2022.
- [D3] **T. Röddiger,** C. Dinse, and M. Beigl. "Wearability and Comfort of Earables During Sleep". In 2021 International Symposium on Wearable Computers. Online, Virtual, 2021.
- [D2] T. Röddiger, D. Doerner, and M. Beigl. "ARMart: AR-based Shopping Assistant to Choose and Find Store Items". In Proceedings of the 2018 ACM International Joint Conference and 2018 International Symposium on Pervasive and Ubiquitous Computing and Wearable Computers. Singapore, Singapore, October 2018.
- [D1] T. Röddiger, M. Beigl, M. Köpke, and M. Budde. "VOCNEA: Sleep Apnea and Hypopnea Detection Using a Novel Tiny Gas Sensor" In Proceedings of the 2018 ACM International Symposium on Wearable Computers. Singapore, Singapore, October 2018.

Technical Reports

- [R2] T. King, Y. Zhou, T. Röddiger, and M Beigl. "MicroNAS: Memory and Latency Constrained Hardware-Aware Neural Architecture Search for Time Series Classification on Microcontrollers". arXiv preprint arXiv:2310.1838. 2023.
- [R1] N. Schwabe, Y. Zhou, L. Hielscher, **T. Röddiger**, T. Riedel, and S. Reiter. "Tools and Methods for Edge-AI-Systems". at-Automatisierungstechnik, 70(9):767–776, 2022.

Patents

[P3]	Sensor System and Methodology for Determining a User's Chewing Behavior,
	(pending), DE102021210223A1.
	Tobias Röddiger, Michael Beigl, Victor Pankratius
[P2]	Discreet Hands- and Eyes-Free Input by Voluntary Tensor Tympani Muscle
	Contraction, (withdrawn), EP4085835A.
	Tobias Röddiger, Christopher Clarke, Michael Beigl

[P1] Sensor System, Evaluation Device, Method and Computer Program Product for Recording a Subject's Sleeping Behavior, (pending), WO2020070126A1. Tobias Röddiger, Matthias Budde, Marcel Köpke, Michael Beigl