Tolga-Can **Çallar**

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Short Biography

Tolga-Can Çallar has been a research associate and doctoral candidate at the Institute of Robotics and Cognitive Systems since 2022, supervised by Prof. Floris Ernst. He completed his M.Sc. in Medical Engineering Science at the Universität zu Lübeck in 2021. His research focuses on trajectory planning and motion control using proprioceptive and image-based models for medical robotics. A particular emphasis lies on the development of autonomous methods for robot-assisted ultrasound imaging.

Current Position

Research Associate and Doctoral Candidate 2022 – present
Institute of Robotics and Cognitive Systems, Universität zu Lübeck
- Research on trajectory planning and motion control based on proprioceptive and image-based models for medical robotics
- Focus: autonomous robot-assisted ultrasound imaging
- Contribution to teaching, including exercises, project supervision, and practical course supervision in medical robotics
- Doctoral thesis topic: Development of a force-sensitive assistance system for automated ultrasound imaging
- Supervisor: Prof. Dr. Floris Ernst

Education

M.Sc. Medical Engineering Science, Universität zu Lübeck Oct. 2018 – Dec. 2021
- Thesis topic: Autonomous force-sensitive motion control for robotic applications in medicine
- Thesis supervisor: Prof. Dr. Elmar Rückert

B.Sc. Medical Engineering Science, Universität zu Lübeck Oct. 2015 – Nov. 2018
- Thesis topic: Development of a simulation system for the exploration of suitable kinematics for robot-assisted ultrasound imaging
- Thesis supervisor: Prof. Dr. Elmar Rückert

Abitur, Leibniz-Gymnasium Bad Schwartau June 2006 – June 2015

Research Projects

ConSensUS – Contextual Sensing in Robotic Ultrasound Imaging 2025 – present
Institute of Robotics and Cognitive Systems, Universität zu Lübeck
- Development of a multimodal sensing concept for context-dependent acquisition of robotic ultrasound data
- Fusion of visual, spatial, and haptic information for robust perception and control
- Objective: improvement of autonomy, adaptivity, and clinical applicability of robotic ultrasound systems

Modeling and Control of Remote Center of Motion (RCM) Mechanisms 2022 – present
Institute of Robotics and Cognitive Systems, Universität zu Lübeck
- Analysis and implementation of RCM constraints for medical robotic systems
- Development of kinematic and control-based approaches for precise compliance with virtual pivot points
- Integration into trajectory planning and motion control methods for minimally invasive applications

Simulation of Ultrasound Imaging Using Surface-Based Ray Tracing 2023 – 2025
Institute of Robotics and Cognitive Systems, Universität zu Lübeck
- Development of a physics-based simulation environment for robot-assisted ultrasound imaging using surface-based ray-tracing methods
- Automated estimation of acoustic material parameters from CT data by mapping Hounsfield units to acoustic properties, such as speed of sound and density
- Integration into planning and control frameworks for realistic generation and evaluation of ultrasound signals

Development of a Force-Sensitive Assistance System for Automated Ultrasound Imaging Jan. 2022 – present
Institute of Robotics and Cognitive Systems, Universität zu Lübeck
- Design and implementation of a force-sensitive assistance system for stable and adaptive guidance of ultrasound probes
- Integration of proprioceptive and image-based information for robust control of probe contact
- Evaluation of the system with regard to reproducibility, stability, and clinical applicability

Autonomous Force-Sensitive Motion Control for Robotic Applications in Medicine Apr. 2020 – Oct. 2021
Institute of Robotics and Cognitive Systems, Universität zu Lübeck
- Identification of dynamic models and image-guided generation of motion patterns for serial robots using machine learning methods

Body Pose Registration from Depth Images Oct. 2019 – Mar. 2020
Institute of Robotics and Cognitive Systems, Universität zu Lübeck
- Generation of body surface models using 3D cameras
- Elastic point-cloud registration with generic patient models
- Spatial localization of target regions for robot-assisted medical applications

Simulation of Optimal Rotational Velocities for Flywheel-Based Inverted Pendulums Oct. 2018 – Feb. 2019
Institute of Medical Electrical Engineering, Universität zu Lübeck
- Physical modeling and simulation of a flywheel-based inverted pendulum
- Implementation of a learning algorithm for adaptive control of the optimal flywheel velocity

Radiation Protection Course Feb. 2018 – Mar. 2018
Institute of Biology, Universität zu Lübeck
- Conducted experiments and laboratory work with radioactive materials

Publications and Research Outputs

Scientific Publications

[1] T.-C. Çallar, R. Golwalkar, and F. Ernst, "Consensus: Contextual sensing in robotic ultrasound imaging using visual, spatial, and haptic data", in 1st German Robotics Conference, March 13–15, 2025, Nuremberg, Germany, Mar. 2025.

[2] T.-C. Çallar and S. Böttger, "Hybrid learning of time-series inverse dynamics models for locally isotropic robot motion", IEEE Robotics and Automation Letters, 2022. DOI: 10.1109/LRA.2022.3222951.

[3] T.-C. Çallar, "Learning of inverse dynamics for proprioceptive force estimation during irregular fine-scale robot motion", Master's thesis, Montanuniversität Leoben, 2021. [Online]. Available: https://cps.unileoben.ac.at/tolga-can-callar-learning-of-inverse-dynamics-for-proprioceptive-force-estimation-during-irregular-fine-scale-robot-motion/.

[4] T.-C. Çallar, S. Böttger, and E. Rueckert, "Generation of 3d body models from single-view range images for robotic applications in medicine", in Student Conference Proceedings Universität zu Lübeck, 2020.

[5] T.-C. Çallar, E. Rueckert, and S. Böttger, "Efficient body registration using single-view range imaging and generic shape templates", Current Directions in Biomedical Engineering, vol. 6, no. 3, pp. 119–122, 2020. DOI: 10.1515/cdbme-2020-3031.

[6] S. Böttger, T.-C. Çallar, A. Schweikard, and E. Rueckert, "Medical robotics simulation framework for application-specific optimal kinematics", Current Directions in Biomedical Engineering, vol. 5, no. 1, pp. 145–148, 2019. DOI: 10.1515/cdbme-2019-0037.

[7] T.-C. Çallar, "Entwicklung eines simulationssystems zur exploration geeigneter kinematiken für die robotisierte ultraschallbildgebung", Bachelor's thesis, Universität zu Lübeck, 2018. [Online]. Available: https://ailab.science/wp/theses/Callar_BscThesis_2018.pdf.

Software and Datasets

[8] T.-C. Çallar, Limodyn, Software, Repository. Accompanying software for: Hybrid Learning of Time-Series Inverse Dynamics Models for Locally Isotropic Robot Motion, 2023. [Online]. Available: https://gitlab.rob.uni-luebeck.de/callar/limodyn.

[9] T.-C. Çallar, Proprioceptive long-term time-series dataset for inverse dynamics modeling in locally isotropic robot motion, Dataset, Multimodal dataset for modeling, validation, and benchmarking of data-driven inverse dynamics models, 2023. [Online]. Available: https://gitlab.rob.uni-luebeck.de/callar/limodyn.

Supervised Theses & Internships

Master's Theses

[10] S. Bhadani, "Position dependent friction identification of a 6-dof robotic manipulator", Supervision: Tolga-Can Çallar; Primary supervisor: Prof. Dr. Floris Ernst, Master's thesis, Universität zu Lübeck, Neura Robotics, 2026.

Bachelor's Theses

[11] H. Ünal, "Variable stiffness actuator for contact force control in robotic ultrasound imaging", Supervision: Tolga-Can Çallar, M.Sc.; Primary supervisor: Prof. Dr. Floris Ernst, Bachelor's thesis, Universität zu Lübeck, 2025.

[12] C. Kaluza, "Design of a remote center of motion manipulator attachment for robotic ultrasound imaging", Supervision: Tolga-Can Çallar; Primary supervisor: Prof. Dr. Floris Ernst, Bachelor's thesis, Universität zu Lübeck, 2024.

Internships

[13] S. Bhadani, "Position-dependent friction identification of a 6-dof robotic manipulator", Master's internship, Universität zu Lübeck, Neura Robotics; Supervision: Tolga-Can Çallar; Primary supervisor: Prof. Dr. Floris Ernst, 2025.

[14] L. M. Gonzalez Villa, "Simulation framework for a collision avoidance inverse kinematics model of a 7 degrees of freedom ultrasound imaging robot", Master's internship, Universität zu Lübeck; Supervision: Tolga-Can Çallar; Primary supervisor: Prof. Dr. Floris Ernst, 2025.

[15] C. Patel, "Development of a kinematic structure for ultrasound guided cannula placement", Master's internship, Technische Hochschule Lübeck; Supervision: Tolga-Can Çallar; Primary supervisor: Prof. Dr. Floris Ernst, 2025.

[16] M. Patel, "Development of a remote center of motion manipulator attachment for robotic ultrasound imaging", Master's internship, supervision: Tolga-Can Çallar; Primary supervisor: Prof. Dr. Floris Ernst, 2025.

Seminar Projects

[17] A. Lascano, "Variable stiffness actuators for robotic applications in medicine", Master's seminar paper, Universität zu Lübeck; Supervision: Tolga-Can Çallar, 2026.

[18] F. Urbini, "Learning-based approaches to inverse kinematics for serial manipulators", Master's seminar paper, Universität zu Lübeck; Supervision: Tolga-Can Çallar, 2026.

[19] J. Brauer, "Collision-avoidant inverse kinematics for robotic arms in a clinical setting", Bachelor's seminar paper, Universität zu Lübeck; Supervision: Tolga-Can Çallar, 2024.

[20] A. Kabour, "Real-time simulation of ultrasound images", Master's seminar paper, Universität zu Lübeck; Supervision: Tolga-Can Çallar, 2024.

[21] L. Martensen, "Model learning for physical human-robot interactions", Master's seminar paper, Universität zu Lübeck; Supervision: Tolga-Can Çallar, 2024.

[22] K. Ahmi, "Path planning for robotic arms in clinical settings", Bachelor's seminar paper, Universität zu Lübeck; Supervision: Tolga-Can Çallar, 2023.

Teaching and Academic Engagement

Medical Robotics 2022 – 2026
Master's module, Prof. Dr. Achim Schweikard, Prof. Dr. Floris Ernst
- Contribution to teaching in the fields of medical robotics and control engineering
- Supervision of exercises and project work, including programming, robotics, and simulation
- Support in the conception and implementation of courses

Learning Inverse Dynamics Models 2023 – 2025
Annual guest lecture, Master's module Advanced Topics in Robotics, Prof. Dr. Ngoc Thinh Nguyen
- Teaching learning-based approaches for modeling inverse dynamics of robotic systems

Head of the Student Community 2022 – 2024
Organization of monthly lecture series for student research projects
- Conceptualization and coordination of a regular lecture series for presenting current student research work
- Promotion of scientific exchange and interdisciplinary networking between students and researchers
- Organization, moderation, and content-related support of the events

Memberships

- IEEE Member
- IEEE Robotics and Automation Society
- Technical Committee, German Society for Biomedical Engineering
- Member, Commission for the Ethics of Security-Relevant Research (KEsF), Universität zu Lübeck

Reviewer for Conferences & Journals

Humanoids 2023 (Austin, USA) (1 review), **ICRA 2024** (Yokohama, Japan) (1 review), **ICRA 2025** (Atlanta, USA) (1 review), **IROS 2025** (Hangzhou, China) (1 review), **ICRA 2026** (Vienna, Austria) (1 review), **IROS 2026** (Pittsburgh, USA) (2 reviews), **IROS 2027** (Florence, Italy) (1 review), **IEEE RA-L** (3 reviews)

Skills

Technical Skills

Programming Languages: C++, Python, Java, Lua

Control Methods: Impedance control, admittance control, visual servoing, MPC, trajectory planning

Machine Learning: Deep learning, time-series models, system identification, PyTorch, TensorFlow

Perception & Computer Vision: OpenCV, RGB-D processing, point-cloud processing, registration

Optimization: Nonlinear optimization, gradient-based methods, trajectory optimization

Robotics & Simulation: ROS, MoveIt, CoppeliaSim, Gazebo, Isaac Sim

Medical Imaging: 3D Slicer, PLUS Toolkit, DICOM, HL7, ultrasound processing

Physics-Based Simulation: Ray tracing, ultrasound simulation, contact modeling

Data Processing: NumPy, SciPy, Pandas, Matplotlib

Systems & Infrastructure: Linux, Docker, Git, SSH, HPC/parallelization

Languages

German (native), **English** (fluent, LCCI Level 3), **Turkish** (native), **Latin** (advanced Latin certificate), **Spanish** (basic knowledge)