Lukas Schmid

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Research Interests

I'm passionate about autonomy for intelligent mobile systems. In particular, my research focuses on active and passive perception and understanding of complex, dynamic, and changing environments for robotic interaction and augmented reality. This includes research on representations of dense geometric and semantic models of an environment, scene abstraction and understanding. I work on extending these map representations to model challenging and dynamic environments, by recognizing short-term moving and long-term changing entities, predicting spatial and temporal changes, and building systems that continuously learn, improve, and adapt over time. My third research area focuses on utilizing these world representations, predictions, and knowledge for active perception and interaction planning. This includes autonomously building such representations and knowledge in unknown environments, active adaptation and learning for robots, and utilizing these world models and knowledge for effective planning. I demonstrate these novel concepts and methods through implementation of the algorithms and approaches on-board compute constrained autonomous mobile robots in interactive real-time missions.

Robotics - AI - Perception - Autonomy - Learning - Mapping - Planning - Inference

Education

7.2019-10.2022 **Dr. Sc. with Autonomous Systems Lab (ASL) at ETH Zürich, CH.**
- Thesis: Robust Active Perception and Volumetric Mapping in Unknown Changing Environments. Cumulative thesis of 6 first-authored papers.
- Supervised by Prof. Roland Siegwart, Cesar Cadena, and Juan Nieto, in collaboration with Prof. Marc Pollefeys, Jeffrey Delmerico, Johannes Schönberger, and Helen Oleynikova at Microsoft.
- Awarded the ETH Medal for outstanding PhD Theses.

9.2017-6.2019 **M. Sc. Robotics, Systems and Control (RSC) at ETH Zürich, CH.**
- Graduated with Distinction.
- Awarded the Willi Studer Prize for the best graduate.
- Awarded the ETH Medal for outstanding Master Theses.

9.2013-9.2016 **B. Sc. Mechanical Engineering at ETH Zürich, CH.**

9.2013-9.2016 **Grammar School in Frauenfeld, CH.**
- Graduated with Distinction.
- Honored with the Outstanding Matura Thesis Award.

Employment

2.2023-current	**Postdoctoral Research Fellow**, MIT, Cambridge, MA, USA.
	○ Working with Prof. Luca Carlone at the MIT-SPARK Lab on higher-level scene understanding and dynamic 3D scene graphs.
10.2022-1.2023	**Postdoctoral Researcher**, ETH Zürich, CH.
	○ Working with Prof. Roland Siegwart at the Autonomous Systems Lab.
11.2021-2.2022	**Visiting Researcher** at Microsoft Mixed Reality and AI Lab, Zürich, CH.
	○ Working with Prof. Marc Pollefeys, Juan Nieto, Jeffrey Delmerico, and Johannes Schönberger on Panoptic Multi-TSDFs and Active Perception in Changing Scenes.
	○ Proposed and started two joint Master Theses, one on Incremental 3D Scene Graph Generation and one on Active Perception for Visual Long-term Re-localization.
7.2019-10.2022	**Doctoral Researcher**, ETH Zürich, CH.
	○ Working with Prof. Roland Siegwart at the Autonomous Systems Lab.
9.2018-2.2019	**Teaching Assistant** at ETH Zürich, with Prof. Joachim Buhmann, D-INFK.
2.2017-6.2017	**Maintenance Engineer** at BOSCH, sia Abrasives Industries AG, 8500 Frauenfeld, CH.
9.2016-2.2017	**Engineering Intern** at BOSCH, sia Abrasives Industries AG, 8500 Frauenfeld, CH, Department of Technical Functions.
1.2014-2.2014	**Workshop Intern**, at Phoenix Mechano, 8260 Stein am Rhein, CH.
2009-2013	5+ shorter periods of work (1-4 weeks) at different companies during breaks.

Publications

Journal Articles

[J1] **Schmid, L,** Andersson, O, Sulser, A, Pfreundschuh, P, and Siegwart, R, "Dynablox: Real-time Detection of Diverse Dynamic Objects in Complex Environments", IEEE Robotics and Automation Letters (RA-L), Vol. 8, No. 10, pp. 6259-6266, 2023.

[J2] Zurbrügg, R, Blum, H, Cadena, C, Siegwart, R, and **Schmid, L**, "Embodied Active Domain Adaptation for Semantic Segmentation via Informative Path Planning", IEEE Robotics and Automation Letters (RA-L), Vol. 7, No. 4, pp. 8691-8698, 2022.

[J3] **Schmid, L,** Ni, C, Zhong, Y, Siegwart, R, and Andersson, O, "Fast and Compute-efficient Sampling-based Local Exploration Planning via Distribution Learning", IEEE Robotics and Automation Letters (RA-L), Vol. 7, No. 2, pp. 7810-7817, 2022.

[J4] **Schmid, L,** Reijgwart, V, Ott, L, Nieto, J, Siegwart, R, and Cadena, C, "A Unified Approach for Autonomous Volumetric Exploration of Large Scale Environments under Severe Odometry Drift", IEEE Robotics and Automation Letters (RA-L), Vol. 6, No. 3, pp. 4504-4511, 2021.

[J5] **Schmid, L,** Pantic, M, Khanna, R, Ott, L, Siegwart, R, and Nieto, J, "An efficient sampling-based method for online informative path planning in unknown environments", IEEE Robotics and Automation Letters (RA-L), Vol. 5, No. 2, pp. 1500-1507, 2020.

[J6] Khanna, R, **Schmid, L,** Walter, A, Nieto, j, Siegwart, R, and Liebisch, F, "A spatio temporal spectral framework for plant stress phenotyping", Plant methods, Vol. 15, No. 1, pp. 1-18, 2019.

Peer-reviewed Conference Papers

[C1] Looper, S, Rodriguez-Puigvert, J, Siegwart, R, Cadena, C, and **Schmid, L,** "3D VSG: Long-term Semantic Scene Change Prediction through 3D Variable Scene Graphs", IEEE International Conference on Robotics and Automation (ICRA), pp. 8179-8186, 2023.

[C2] **Schmid, L,** Delmerico, J, Schönberger, J, Nieto, J, Pollefeys, M, Siegwart, R, and Cadena, C, "Panoptic Multi-TSDFs: a Flexible Representation for Online Multi-resolution Volumetric Mapping and Long-term Dynamic Scene Consistency", IEEE International Conference on Robotics and Automation (ICRA), pp. 8018-8024, 2022.

[C3] **Schmid, L,*** Lionar, S, Cadena, C, Siegwart, R, and Cramariuc, A, "NeuralBlox: Real-Time Neural Representation Fusion for Robust Volumetric Mapping", IEEE International Conference on 3D Vision (3DV), pp. 1279-1289, 2021.

[C4] **Schmid, L,*** Digumarti, T, Rizzi, G, Nieto, J, Siegwart, R, Beardsley, P, and Cadena, C, "An approach for semantic segmentation of tree-like vegetation", IEEE International Conference on Robotics and Automation (ICRA), pp. 1801-1807, 2019.

Peer-reviewed Workshop Contributions

[W1] Müller, M, Lim, J, **Schmid, L,** Blum, H, Stürzl, W, Gawel, A, Siegwart, R, and Triebel, R, "Interactive OAISYS: A photorealistic terrain simulation for robotics research", IEEE ICRA Workshop on Releasing Robots into the Wild: Simulations, Benchmarks, and Deployment, Philadelphia (PA), USA, May, 2022.

Preprints

[P1] **Schmid, L,** Abate, M, Chang, Y, and Carlone, L, "Khronos: A Unified Approach for Spatio-Temporal Metric-Semantic SLAM in Dynamic Environments", ArXiv Preprint, 2024.

[P2] **Schmid, L,** Cheema, M, N, Reijgwart, V, Siegwart, R, Tombari, F, and Cadena, C, "SC-Explorer: Incremental 3D Scene Completion for Safe and Efficient Exploration Mapping and Planning", ArXiv Preprint arXiv:2208.08307, 2022. Late breaking result at ICRA 2023.

Other

[O1] **Schmid, L,** "Robust Active Perception and Volumetric Mapping in Unknown Changing Environments", Doctoral Thesis, ETH Zurich, 2022.

[O2] **Schmid, L,** "Active Path Planning for 3D Reconstruction with UAVs", Master Thesis, ETH Zurich, 2022.

* Indicates shared first author, second listed.

Awarded Grants

2022   Swiss National Science Foundations (SNSF) Postdoc.Mobility Career Grant, "Robust Robotic Scene Understanding in Complex, Changing Environments using 3D Dynamic Scene Graphs".

Awards and Honors

2023   ETH Medal for outstanding PhD thesis.
2020   Willi Studer Prize for the best graduate in M.Sc. RSC at ETH Zürich.
2020   ETH Medal for outstanding master thesis.
2013   Grammar School Frauenfeld Award for excellent graduates.
2013   Grammar School Frauenfeld Award for outstanding matura thesis.

Invited Talks

4.2024   "Khronos: From Simultaneous Localization and Mapping to Spatio-temporal Perception of Shared Dynamic Scenes", to be presented at the *Rising Stars Seminar*, University of Michigan, USA.

10.2023   "Semantics and Learning for Active Robot Perception in Dynamic Environments", presented at the *MIT Machine Learning Tea Talk Series*, MIT, USA.

12.2022   "Robust Active Perception and Volumetric Mapping in Unknown Changing Environments", presented at the *Joint Control and Robotics Seminar*, University of Manchester, United Kingdom.

4.2022   "Semantics and Learning for Robust Active Perception in Changing Environments", presented at the *Semantic Perception Reading Group*, Google Zürich, Switzerland.

3.2022   "Robust Volumetric Mapping in Changing Environments", presented at the *Microsoft Swiss Joint Research Center Workshop*, Lausanne, Switzerland.

4.2021   "Volumetric Mapping for Long-term Robot Interaction", presented at the *Microsoft Swiss Joint Research Center Workshop*, Virtual.

1.2020   "A Modular Approach for Lifelong Mapping from End-User Data", presented at the *Microsoft Swiss Joint Research Center Workshop*, Lausanne, Switzerland.

Professional Activities

Organization of Conferences

2024   **MIT LIDS Student Conference.**
- Conference scientific program co-chair.
- Invited distinguished plenary speakers.
- Organized and moderated the distinguished speaker panel discussion.
- Program and session chair "Algorithms, Optimization, & Game Theory".

Reviewer for International Journals and Conferences

2020-current   **Reviewer for International Journals.**
- IEEE Transaction on Robotics (T-RO) — 2022, 2023
- International Journal on Robotics Research (IJRR) — 2023, 2024
- Autonomous Robots — 2023
- IEEE Robotics and Automation Letters (RA-L) — 2020-2024
- Journal of Pattern Recognition — 2022
- IEEE/CAA Journal of Automatica Sinica — 2022

2021-current   **Reviewer for International Conferences.**
- Robotics: Science and Systems (RSS) — 2023, 2024
- IEEE Int. Conf. on Robotics and Automation (ICRA) — 2021-2024
- IEEE/RSJ Int. Conf. on Intelligent Robots and Systems (IROS) — 2021-2023

2021-current   **Reviewer for International Conference Workshops.**
- Conf. on Neural Information Processing Systems (NeurIPS) — 2021

Technical Societies and Committees

2019-current   **IEEE Robotics and Automation Society (RAS), Member.**

Teaching

Guest Lectures

2024   **Mobile Robotics: Methods and Algorithms**, graduate class, University of Michigan, USA.
- Guest lecture on "Perception Algorithms for Dynamic Scenes".

2023   **Visual Navigation for Autonomous Vehicles**, graduate class, MIT, USA.
- Guest lecture on "Visual Odometry".

Teaching Assistant

Selected topics, prepared materials, and taught theory review sessions. Selected topics, designed, and graded pen and paper problem sets. Designed, supported, and graded coding problem sets. Proposed and supervised research project works. Held Q&A sessions and colloquia. Designed and verified exam questions. Supervised and corrected written exams.

2023	**Visual Navigation for Autonomous Vehicles**, graduate class, MIT, USA.
2020-2022	**Autonomous Mobile Robots**, M.Sc. class, ETH Zurich, CH.
2020-2022	**Perception and Learning for Robotics**, M.Sc. class, ETH Zurich, CH.
2018	**Advanced Machine Learning**, M.Sc. class, ETH Zurich, CH.

Didactic Education and Training

2023	**Preventing Sexual Harassment and Power Dynamics**, online course, MIT, 2023.
2022	**Power and Leadership**, 6 month course, ETH Zürich.
2022	**Selection Procedures and Bias**, half-day workshop, ETH Zürich.
2018	**Didactics for Teaching Assistants**, 1 full week training, ETH Zürich.

Mentoring

Advised 40+ students in research projects. Co-advised PhD student in research projects. Proposed, supervised, and graded M.Sc. and B.Sc. theses and other research projects.

PhD Students

2023-current	**Marcus Abate and Yun Chang**, "Spatio-temporal SLAM in Dynamic Scenes", MIT.
2023-current	**Dominic Maggio**, "Open-set Scene Understanding with 3D Dynamic Scene Graphs", MIT.
2023	**Julio Placed**, "Active Perception for 3D Dynamic Scene Graphs", visiting student from University of Zaragoza, Spain, MIT.

M.Sc. Theses

The M.Sc. thesis is a 6 month full-time project.

2023	**Nicolas Gorlo**, "Long-term Human Motion Prediction with 3D Scene Graphs", visiting student from ETH Zurich, CH, MIT.
2022	**Jiaqi (Julia) Chen**, "Active Perception for Long-term Re-localization", in collaboration with Microsoft Mixed Reality and AI Lab, ETH Zurich.

2022	**Samuel Looper**, "Planning in Latent Neural Representations", ETH Zurich.
2022	**Friedrich Rockenbauer**, "Co-operative Informative Path Planning for Safe Navigation in Unknown Scenes", ETH Zurich.
2021	**Giuliano Albanese**, "Active Perception for Accurate Panoptic Segmentation", ETH Zurich.
2021	**Ioannis Athanasiadis**, "Spatio-temporally consistent Mapping using Collections of Submaps", ETH Zurich.
2021	**Adrian Brandemühl**, "Tighlty Coupled Lidar-Visual-Inertial-Odometry with TSDFs", ETH Zurich.
2021	**Mansoor Cheema**, "Leveraging Scene Completion for Exploration", visiting Student from Technical University of Munich, Germany, ETH Zurich.
2021	**Samuel Gull**, "Towards Map-based Motion Detection", ETH Zurich.
2021	**Stefan Lionar**, "Neural Representation Fusion for Volumetric Mapping", ETH Zurich. ○ Published at the IEEE International Conference on 3D Vision (3DV), 2021.
2021	**Viviane Marty**, "Incremental 3D Scene-Graph Construction", in collaboration with Microsoft Mixed Reality and AI Lab, ETH Zurich.
2021	**Rene Zurbrügg**, "Continual Learning for Semantic Segmentation", ETH Zurich. ○ Published in the IEEE Robotics and Automation Letters (RA-L), 2022. ○ Awarded the ETH Medal for Outstanding Master Theses.
2020	**Davide Bagheri**, "Volumetric Exploration subject to Drift", visiting student from University di Pisa Sant'Anna, Italy, ETH Zurich.
2020	**Slaven Cvijetic**, "Biology-inspired Odometry Fusion", ETH Zurich.
2020	**Yves Schär**, "Path Planning for Art Installation", ETH Zurich.
2020	**Arno Vaillancourt**, "Leveraging Scene Completion for Exploration", visiting student from EPFL, CH, ETH Zurich.

Semester Theses

The semester thesis is a 14 weeks of 60% effort project of M.Sc. students.

2022	**Annamalai Lakshmanan**, "Efficient Neural Representations for Robotic Mapping", ETH Zurich.
2022	**Aurelio Sulser**, "Towards Map-based Motion Detection", ETH Zurich. ○ Published in the IEEE Robotics and Automation Letters (RA-L), 2023.
2022	**Max Wilder-Smith**, "Autonomous Long-term Data Collection and Mapping", ETH Zurich.
2021	**Junting Chen**, "Incremental 3D Scene-Graph Construction", ETH Zurich.

2021	**Dominik Hollidt**, "Photo-realistic simulation for Autonomous Racing", ETH Zurich.
2021	**Zador Pataki**, "How to Fuse: Incremental Fusion of Neural Semantic Features", ETH Zurich.
2020	**Tiancheng Hu**, "Object Instance Re-localization from Pointclouds", ETH Zurich.
2020	**Konstantinos Skovolas**, "Semantic Abstractions for Localization", ETH Zurich.

B.Sc. Theses

The B.Sc. thesis is a 14 weeks of 60% effort project of B.Sc. students.

2022	**Samuel Bamert and Gabriel Käppeli**, "Geranos-Navigation: Path Planning and Obstacle Avoidance with an UAV Carrying Poles", ETH Zurich.
2020	**Pascal Auf der Maur and Patricia Hörman**, "IMU State Estimation for a Snake-like Robot", ETH Zurich.

Perception and Learning for Robotics

The perception and learning for robotics project is a 14 week part-time project of M.Sc. students.

2022	**Haoran Chen and Weining Ren**, "Neural Implicit Mapping of Dynamic Scenes", ETH Zurich.
2022	**Samuel Looper and Shao Zhou**, "Predicting the Future with Dynamic Scene Graphs", ETH Zurich. ○ Published at the IEEE Interantional Conference on Robotics and Automation (ICRA), 2023.
2021	**Zador Pataki and Amir Hadzic**, "Incremental Map-based Object Segmentation", ETH Zurich.
2021	**Chuqiao Li and Yiming Zhao**, "Leveraging Object Completion for Re-localization", ETH Zurich.
2021	**Chao Ni and Yuliang Zhong**, "Towards Learning-based Exploration Planning", ETH Zurich. ○ Published in the IEEE Robotics and Automation Letters (RA-L), 2022.
2020	**Sirish Srinivasan and Yaswanth Mummaneni**, "Towards Learning-based Exploration Planning", ETH Zurich.

Other Students

2008-2015	**Supervised 10+ students in private mathematics and physics classes.** ○ Middle school, grammar school, and adult qualification to university entrance (TSME) students. ○ Admission or final exam preparations (with 100% success rate).

Service

Departmental Committees

2.2021-2.2023   **Department Commission, Department of Mechanical and Process Engineering (D-MAVT), ETHZ.**
- Scientific staff representative in the department commission.
- Voted on strategic and other departmental decisions together with all faculty and selected student, administrative, and scientific staff representatives.

2.2021-2.2023   **Teaching Commission, Department of Mechanical and Process Engineering (D-MAVT), ETHZ.**
- Scientific staff representative in the teaching commission.
- Reviewed proposals to add, remove, or change classes taught at B.Sc. and M.Sc. level.
- Analyzed and approved class satisfaction evaluations inquired from all students. Discussed and addressed unsatisfactory class ratings with the corresponding PIs.
- Analyzed and approved exam satisfaction evaluations and grade distributions for examination sessions. Discussed and addressed unsatisfactory exam ratings with the corresponding PIs.

Working Groups

2.2022-8.2023   **Working Group designing the New Curriculum of B.Sc. Mechanical Engineering at ETHZ.**
- Co-developed strategic goals to best equip B.Sc. Mechanical Engineering (ME) students for the future.
- Successfully advocated for increased training in computer science, programming, and machine learning for ME students.
- Helped balance class and project work for strong theoretical and practical skill development of ME students.
- Helped streamline offered classes for optimal subject coverage and reduced overlap.

Associations

7.2023-current   **Member of Board, MIT Postdoctoral Assocation (MIT-PDA), MIT.**
- Chair of the Advocacy Committee.
- Represented all postdocs at MIT in collaboration with the Office of the Vice President for Research.
- Organized seminars on US Visa and Permanent Residence for postdocs, in collaboration with

2.2021-2.2023   **Member of Board, Association of Scientific Staff of the Department of Mechanical and Process Engineering (AV-MAVT), ETH Zürich.**
- Represented PhDs and postdocs in the department commission.

- ○ Represented of PhDs and postdocs in the dept. teaching commission.
- ○ Organized of events connecting scientific staff from different labs.

6.2018-6.2022 **Member of Board, Student Wine Association Zürich (SWAZ).**
- ○ Joint association of ETHZ and University Zürich.
- ○ Organized multi-disciplinary networking events connecting students from various backgrounds and interests.
- ○ Organized and taught seminars about specific wines, regions, or varietals.
- ○ Co-managed collaboration with industry partners (Landolt, Zweifel, Baur au Lac, Mövenpick, Smith&Smith, Rare Wines, Provins, and others).

Languages

German	Mother Tongue. Also includes Swiss German.
English	Fluent. Level C2, Cambridge Certificate in Advanced English (CAE), Grade A, 2013. 5+ years of study and work in English.
French	Conversant. Level B2, Diplôme d'Études en Langue Française (DELF), 2012.

Skills

Programming	C++, Python, LaTex, C#, Matlab, and VisualBasic.
Open-source	I am a strong proponent of open-source code and make most of my projects publicly available. A selection is given below, more can be found `here`: `https://github.com/ethz-asl/panoptic_mapping`, `https://github.com/ethz-asl/mav_active_3d_planning`, `https://github.com/ethz-asl/glocal_exploration`, `https://github.com/ethz-asl/unreal_airsim`, `https://github.com/MIT-SPARK/config_utilities`
Simulation	Unreal Engine 4, AirSim, Unity, Gazebo, CoppeliaSim, Siemens NX CAD, and COMSOL Multiphysics FEM.
Robotics	ROS, Matlab, and Simulink.
UAVs	BAZL/EASA UAV Operator License Categories A1/A3.
Deep Learning	PyTorch, Tensorflow, Keras, and SciKit Learn.
IT	Maintained websites and newsletters for multiple associations.

Interests

Besides my work, I am a passionate classical pianist (four times winner of the 1st prize at the Thurgauer Youth Music Competition, 3 times with award). Furthermore, I enjoy team sports such as volleyball, especially beach volleyball during summer. I love exploring, tasting, and presenting wines (WSET Level 2 Award in Wines, WSET Level 2 Award in Spirits, both passed with distinction) and sharing these experiences with others. For recreation, I relish various water sports such as scuba diving (PADI Advanced Open Water Diver), sailing (Swiss Yachting Certificate) as well as wave, wake, and wind surfing.