Recent Advances in Perception for Mobile Robotics

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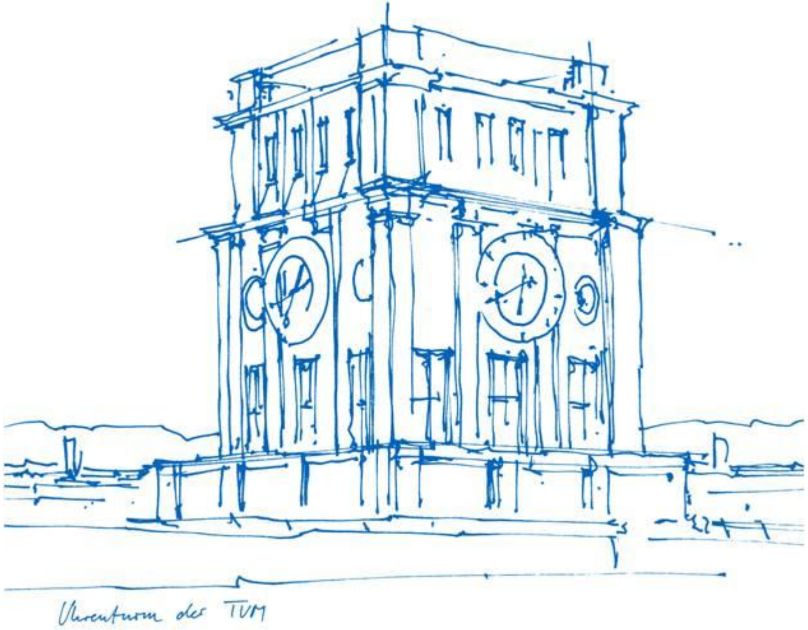
Smart Robotics Lab

Technical University of Munich

WS 2021 / 22



Outline

- General Information
  - About the seminar
  - Registration
- Papers
  - New sensor types and sensor fusion for VIO & SLAM
  - 3D Representations / Dense Mapping
- Questions

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How is the seminar organized?

- Slides / Material: seminar webpage
  - https://srl.in.tum.de/teaching/w21/seminar_moro
  - Password: moro_ws21 − Material page will soon go online

- Questions / Meeting arrangement: contact organizers
  - moro-ws21@srl.in.tum.de

How is the seminar organized?

- Seminar meetings: talks and discussion
  - Time: Tuesdays, 10:00-12:00
  - Room: MI 02.09.023
  - Starting date: TBA (web page)
  - Number of meetings: TBA
  - **Attendance is mandatory!**

- Talk preparation / contact with supervisor
  - Read through your paper and write down what you don't understand
  - Approx. **one month before talk**(optional, but recommended): meet supervisor for questions
  - **One week before talk** (optional, but recommended) talk: meet supervisor to go through slides
  - **One week before talk** (mandatory) talk: send slides to your supervisor
  - **Two weeks after** talk: submit your report via email

What about the presentation?

- General setup:
  - Duration: 20-25 minutes talk + 10-15 minutes discussion
  - Make sure to **finish on time**!
  - Rule of thumb: 1-2 minutes per slide → 10-20 slides
  - Do not put too much information on the slides!

- Recommended structure (talk only):
  - Introduction
  - Overview / Outline
  - Method description
  - Experiments and results
  - Personal comments
  - Summary

What about the final report?

- General setup:
  - Use LATEX template provided on web page
  - Length: 4-5 pages
  - Send final report as pdf by email to moro-ws21@srl.in.tum.de
  - Submission deadline: **two weeks after talk**

- Recommended structure (main text only):
  - Introduction
  - Related work
  - Method description
  - Experiments and results
  - Discussion of results
  - Summary

Summary: how will the seminar be graded?

- The final grade will be based on
  - Presentation
  - Final Report
  - Contributions to seminar discussions

    ⇒ Ask questions!

    ⇒ There are no stupid questions!

How do you register for the seminar?

- Step 1: Official registration via TUM matching system
  - Go to matching.in.tum.de
  - Register for seminar named “Recent Advances in Perception for Mobile Robotics”

- Step 2: Personal registration via email
  - In the list of papers on the web page, select your **three** favorites
  - Write an email ranking these three favorites to moro-ws21@srl.in.tum.de
  - Email subject: “MoRo seminar application [your name]”
  - Include information about related lectures / courses you have taken so far.
  - We do **not** need a CV or a motivation letter!
  - **Registrations without email / emails with missing information will be ignored**!

- Deadline for both registrations: July 20, 2021

How do we select candidates and papers?

- Candidate selection
  - Only students registered in the matching system **AND** with emails containing all required information will be considered
  - Among students meeting the formal criteria, selection will be random (matching system)
  - You will get notified by the matching system about the decision (July 29, 2021)

- Paper assignment
  - Papers are assigned after the participant list is finalized
  - We give our best to accommodate your preference list in the assignment

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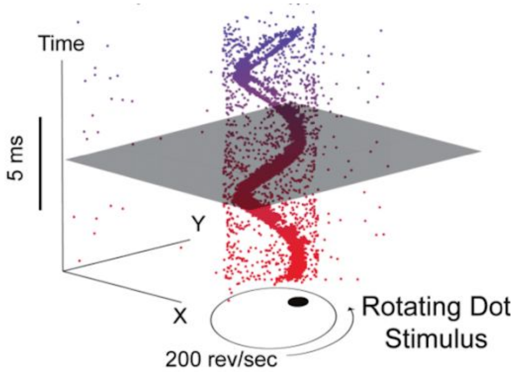
A 128× 128 120 dB 15 μs Latency Asynchronous Temporal Contrast Vision Sensor

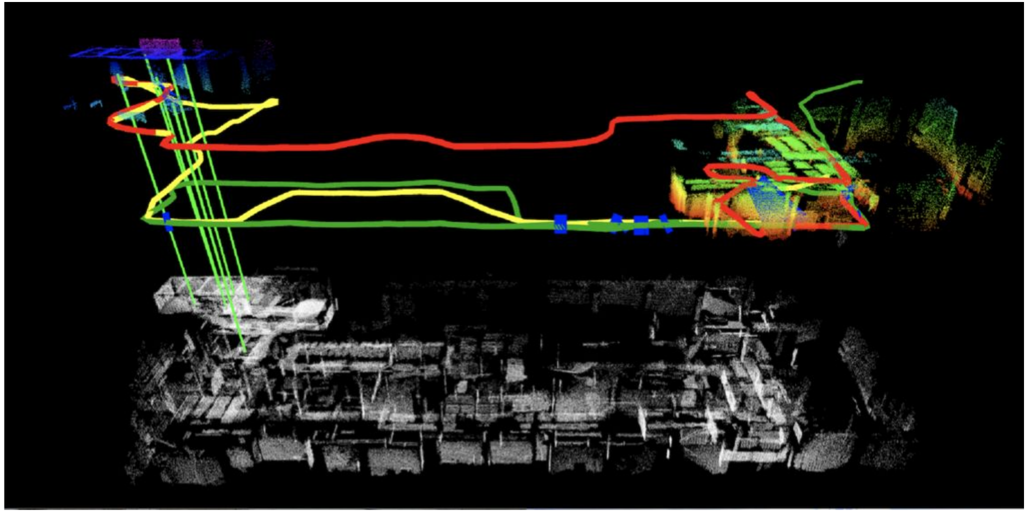
Initial paper about event cameras as low-latency, asynchronous, and efficient imaging sensor that only reflects changes in the environment



Patrick Lichtsteiner, Christoph Posch, Tobi Delbruck (IEEE Journal of Solid-State Circuits)

An online multi-robot SLAM system for 3D LiDARs

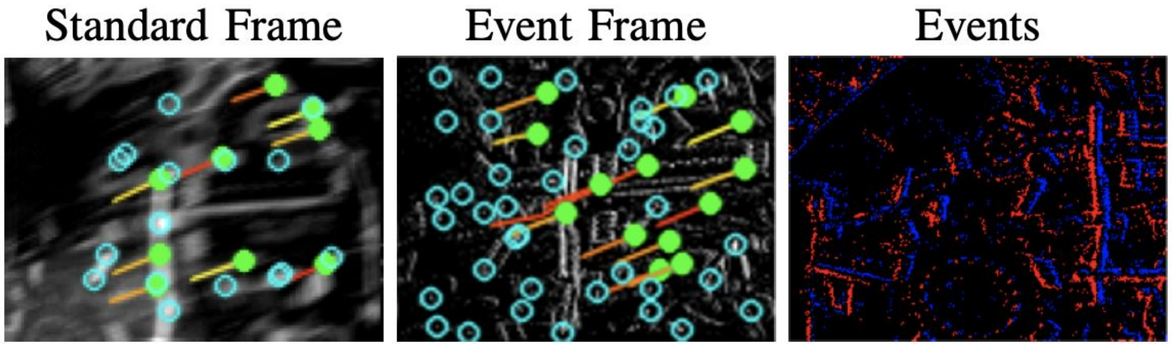
Online localization and mapping system for multiple robots equipped with 3D LiDARs for unstructured, ill-lighted scenarios using sparse, incremental pose-graph optimization



Renaud Dubé, Abel Gawel, Hannes Sommer, Juan Nieto, Roland Siegwart, Cesar Cadena (IROS 2017)

Ultimate SLAM? Combining Events, Images, and IMU for Robust Visual SLAM in HDR and High Speed Scenarios

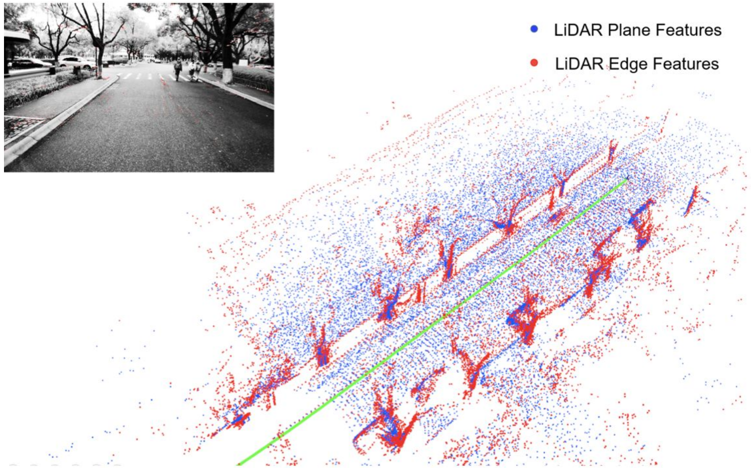
VIO pipeline combining events, images and imu to yield robust and accurate state estimation in HDR and high-speed scenarios



Antoni Rosinol Vida, Henri Rebecq, Timo Horstschaefer and Davide Scaramuzza (RAL 2018)

LIC-Fusion: LiDAR-Inertial-Camera Odometry

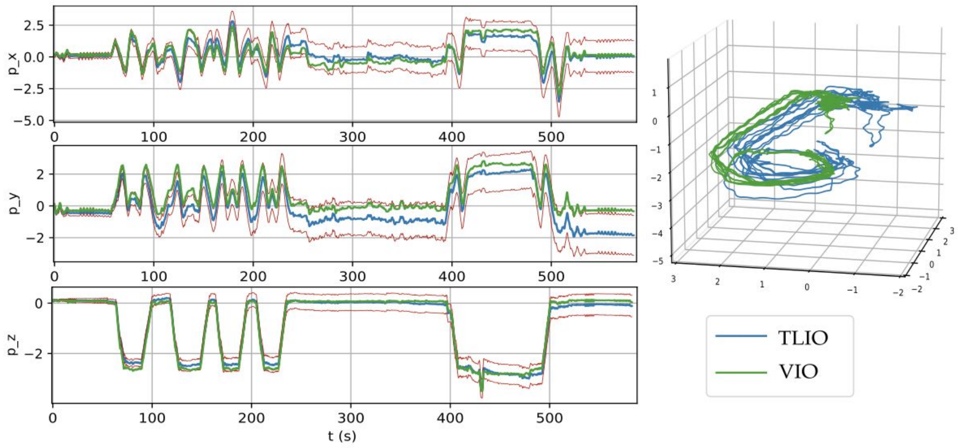
Tightly-coupled fusion of LiDAR, camera and IMU for odometry, including a spatial-temporal online calibration for all of the sensors



Xingxing Zuo, Patrick Geneva, Woosik Lee, Yong Liu, and Guoquan Huang (IROS 2019)

TLIO: Tight Learned Inertial Odometry

Tightly-coupled extended Kalman Filter framework for learned IMU-only state estimation



Wenxin Liu, David Caruso, Eddy Ilg, Jing Dong, Anastasios I. Mourikis, Kostas Daniilidis, Vijay Kumar, and Jakob Engel (IEEE RAL 2020)

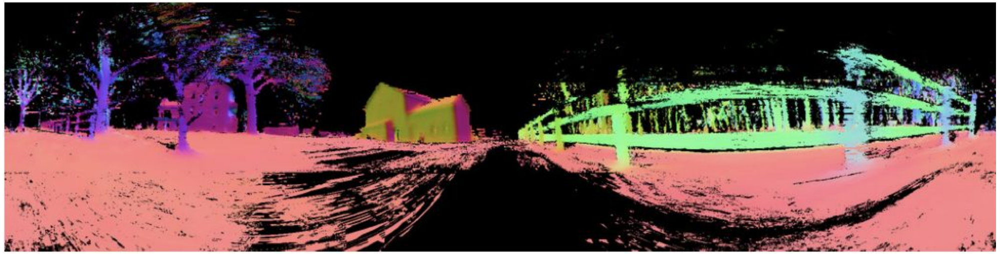
Self-supervised Learning of LiDAR Odometry for Robotic Applications

LiDAR odometry estimate using all available LiDAR data in real-time based on self-supervised learning

Julian Nubert, Shehryar Khattak and Marco Hutter (IROS 2021)

UPSLAM: Union of Panoramas SLAM

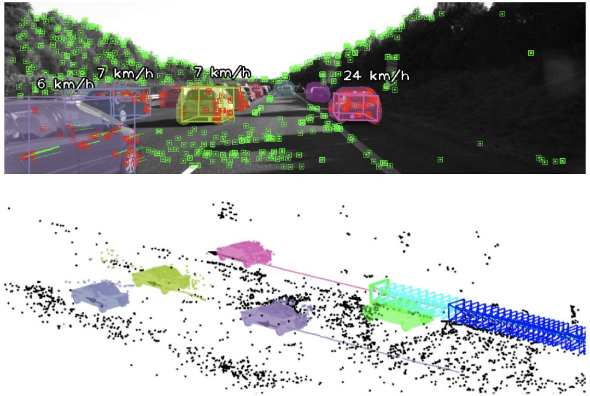
empirical investigation of a new mapping system based on a graph of panoramic depth images



Anthony Cowley, Ian D. Miller and Camillo Jose Taylor (2021)

DynaSLAM II: Tightly-Coupled Multi-Object Tracking and SLAM

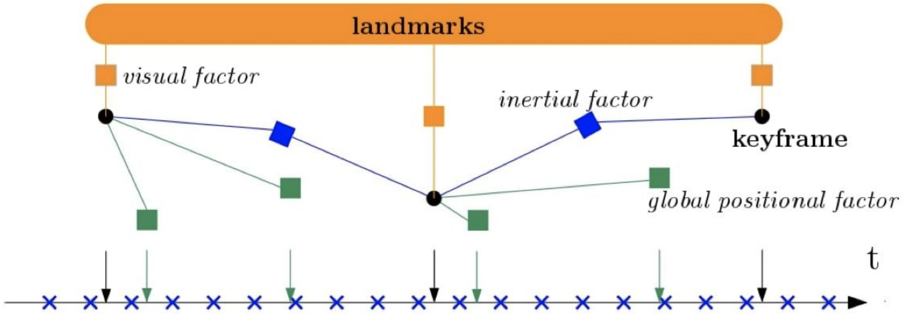
Visual SLAM system for stereo and RGB-D configurations that tightly integrates multi-object tracking



Berta Bescos, Carlos Campos, Juan D. Tardós and José Neira (RAL 2021)

Tightly-coupled Fusion of Global Positional Measurements in Optimization-based Visual-Inertial Odometry

Tight fusion of GPS, images and IMU measurements to nonlinear-optimization-based 6DOF pose estimator resulting in globally consistent estimates and negligible increase of optimization cost



Giovanni Cioffi, Davide Scaramuzza (ICRA 2021)

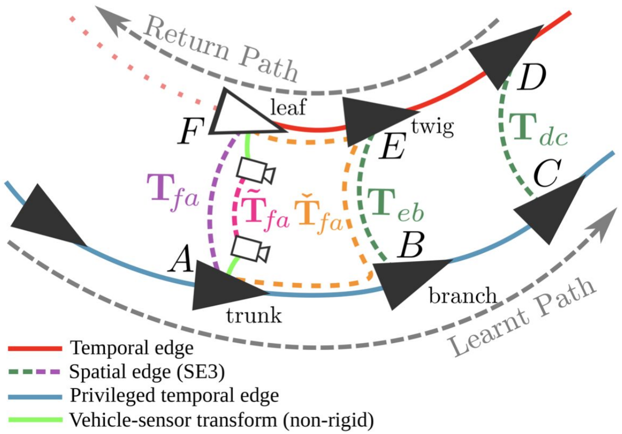
Redesigning SLAM for Arbitrary Multi-Camera Systems

Adaptive SLAM system that works for arbitrary multi-camera setups by generalizing common building blocks for a general multi-sensor case

Juichung Kuo, Manasi Muglikar, Zichao Zhang, Davide Scaramuzza (ICRA 2021)

There's No Place Like Home: Visual Teach and Repeat for Emergency Return of Multirotor UAVs During GPS Failure

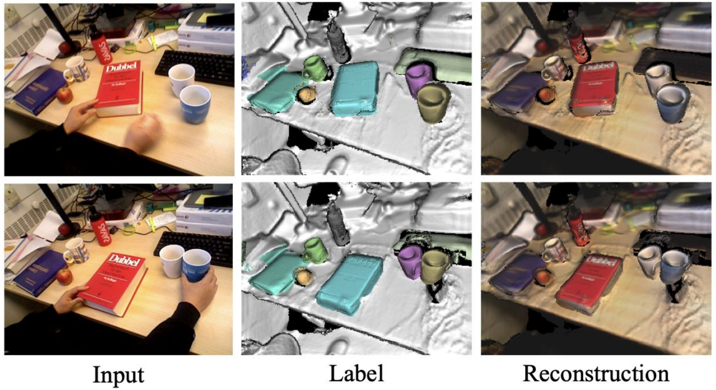
Vision-based route-following system for the autonomous, safe return of UAVs under primary navigation failure such as GPS jamming using visual teach & repeat framework



Michael Warren, Melissa Greeff, Bhavit Patel, Jack Collier, Angela P. Schoellig, Timothy D. Barfoot (IEEE Robotics and Automation Letters 2019)

MID-Fusion: Octree-based Object-Level Multi-Instance Dynamic SLAM

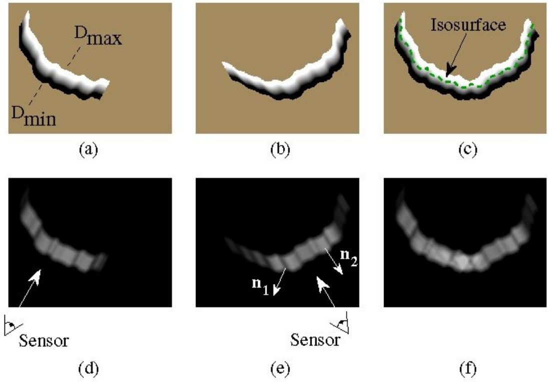
RGB-D SLAM system using an object-level octree-based volumetric representation, robust camera tracking in dynamic environments and at the same time, continuously estimate geometric, semantic, and motion properties for arbitrary objects in the scene

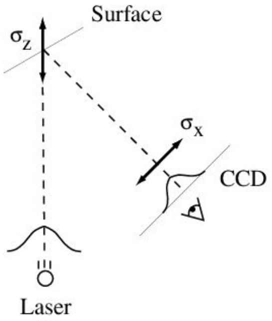


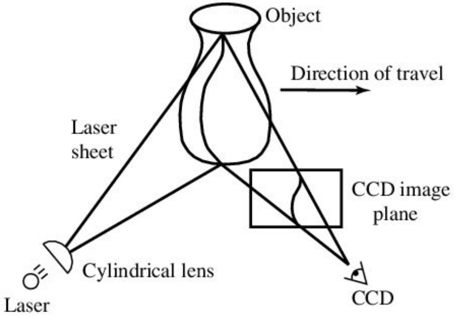
Binbin Xu, Wenbin Li, Dimos Tzoumanikas, Michael Bloesch, Andrew Davison, Stefan Leutenegger (ICRA 2019)

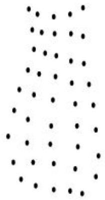
A Volumetric Method for Building Complex Models from Range Images

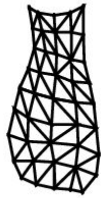
Introduction of Truncated Signed Distance Function (TSDF) for volumetric reconstruction







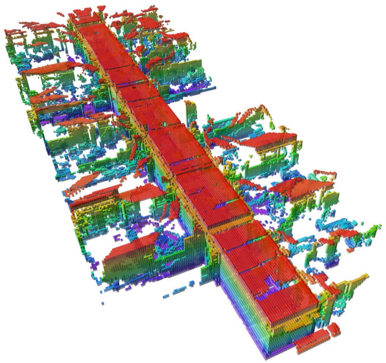




Brian Curless and Marc Levoy (SIGGRAPH 1996)

OctoMap: A Probabilistic, Flexible, and Compact 3D Map Representation for Robotic Systems

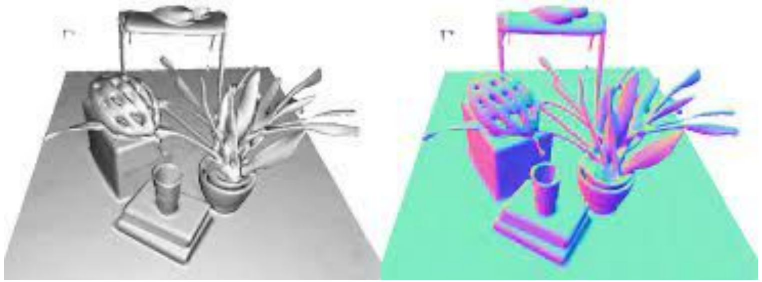
Approach for modeling 3D environment based on octrees using probabilistic occupancy estimation



Armin Hornung, Kai M. Wurm, Maren Bennewitz, Cyrill Stachniss and Wolfram Burgard (ICRA 2010)

KinectFusion

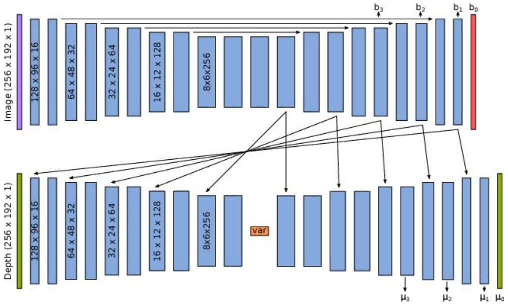
Highly cited, impactful, baseline method for 3D reconstruction using RGB-D cameras

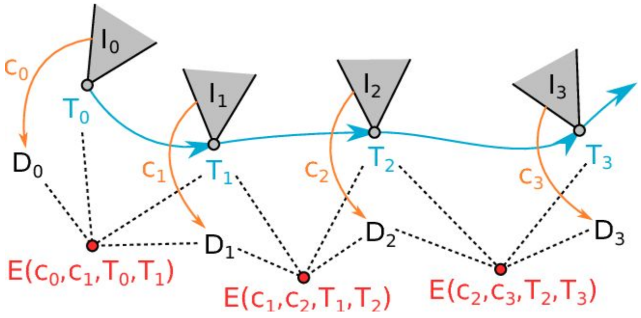


Richard A. Newcombe, Shahram Izadi, Otmar Hilliges, David Molyneaux, David Kim, Andrew J. Davison, Pushmeet Kohi, Jamie Shotton, Steve Hodges and Andrew Fitzgibbon (ISMAR 2011)

CodeSLAM

Learning a compact, optimisable representation of the scene geometry

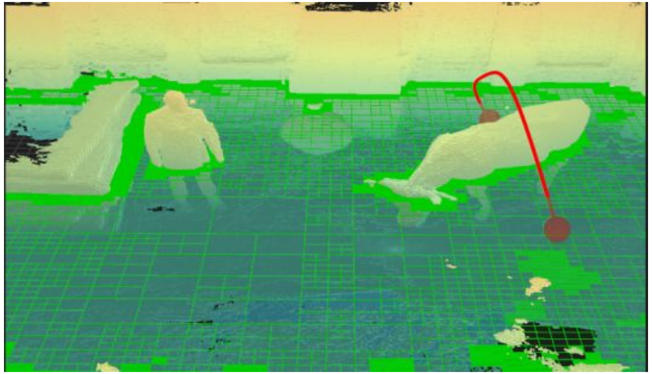


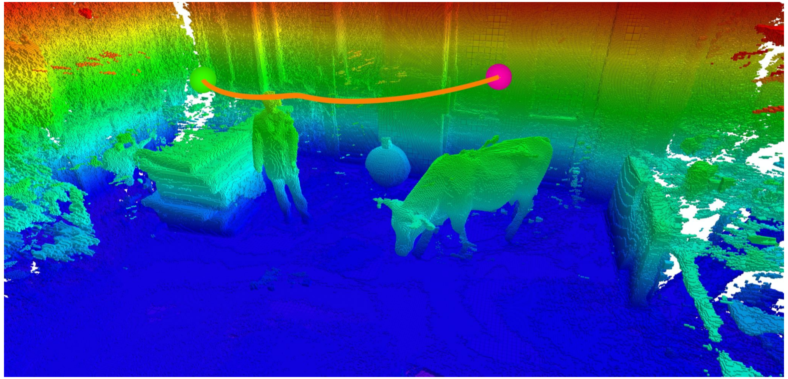


Michael Bloesch, Jan Czarnowski, Ronald Clark, Stefan Leutenegger and Andrew J. Davison (CVPR 2018)

Multi-Resolution 3D Mapping with Explicit Free Space Representation for Fast and Accurate Mobile Robot Motion Planning

Efficient approach for adaptive-resolution volumetric mapping based on occupancy probabilities

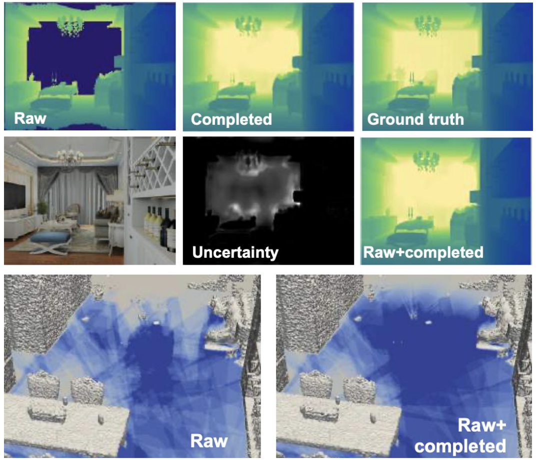




Nils Funk, Juan Tarrio, Sotiris Papatheodorou, Marija Popovic, Pablo F. Alcantarilla, and Stefan Leutenegger (ICRA 2021)

Volumetric Occupancy Mapping With Probabilistic Depth Completion for Robotic Navigation

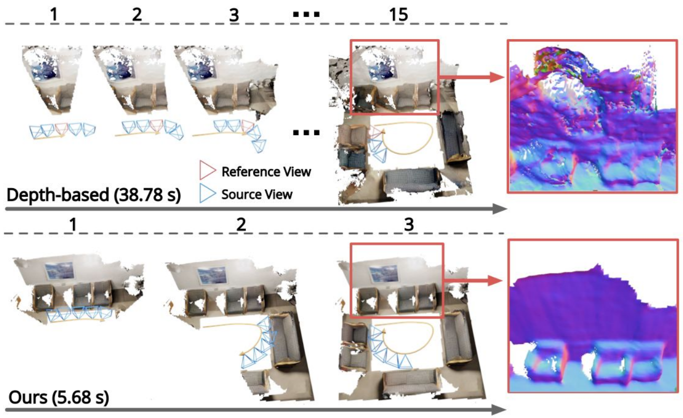
Probabilistic depth completion of RGB-D images using deep learning for valid depth values on shiny, glossy, bright, or distant surfaces (among others)



Marija Popović, Florian Thomas, Sotiris Papatheodorou, Nils Funk, Teresa Vidal-Calleja, Stefan Leutenegger (IEEE Automation Letters 2021)

NeuralRecon: Real-Time Coherent 3D Reconstruction from Monocular Video

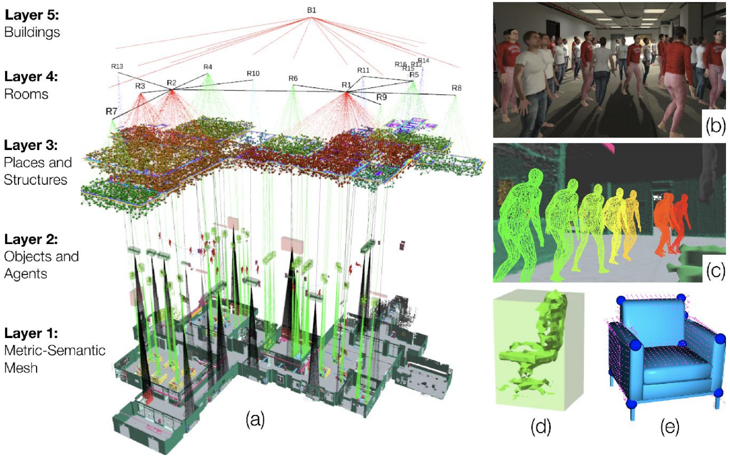
Directly reconstruct local surfaces represented as sparse TSDF volumes for each video fragment sequentially by a neural network for real-time 3D reconstruction from camera data



Jiaming Sun, Yiming Xie, Linghao Chen, Xiaowei Zhou, Hujun Bao (CVPR 2021)

Kimera: from SLAM to Spatial Perception with 3D Dynamic Scene Graphs

Dynamic environments are modelled as 3D Dynamic Scene Graph capturing spatial concepts at different levels of abstraction



Antoni Rosinol, Andrew Violette, Marcus Abate, Nathan Hughes, anYund Chang, Jingnan Shi, Arjun Gupta, and Luca Carlone (2021)

Where can I find the papers?

arxiv.org

IEEE Xplore

sign in with your TUM account

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- Password: moro_ws21
- Contact: moro-ws21@srl.in.tum.de
- **Can I present another paper?** You can also suggest a paper that you are interested in! If you have a paper in mind, that you are interested in and that is not in the list, we are always open for suggestions. In that case, attach it to your three favorite papers and we will decide whether it fits.