mfi21

Karlsruhe

Welcome

Welcome to the 2021 IEEE International Conference on Multisensor Fusion and Integration for Intelligent Systems, MFI 2021, one of the premier forums for the exchange of the latest research results in information fusion, its applications, and its impact on our society. The conference brings together researchers and practitioners from industry, government, and academia to report on the latest scientific and technical advances.

After the virtual MFI 2020, MFI 2021 is held in a hybrid format for the first time in its history. We thus give researchers around the world the opportunity to converse and socialize in person even in these difficult times while also enabling everybody else who cannot or does not want to travel to present their ideas and engage in insightful discussions.

No matter if you are here with us, in your office, or at home – we wish you a fruitful and memorable conference!

On behalf of the Organizing Committee, Conference General Chairs

Uwe Hanebeck   **Florian Pfaff**

Plenary Talks

Thursday, September 23, 13:00 – 14:00
Davide Scaramuzza
University of Zurich, Switzerland

Event Cameras

Event cameras are bio-inspired vision sensors with microsecond latency and resolution, much larger dynamic range, and hundred times lower power consumption than standard cameras. This talk will present current trends and opportunities with event cameras and their challenges.

Davide Scaramuzza is a Professor of Robotics and Perception at the University of Zurich, where he does research at the intersection of robotics, computer vision, and machine learning, and aims to enable autonomous, agile navigation of micro drones using both standard and neuromorphic event-based cameras. He pioneered autonomous, vision-based navigation of drones, which inspired the NASA Mars helicopter and has served as a consultant for the United Nations's International Atomic Energy Agency's (IAEA) Fukushima Action Plan on Nuclear Safety. For his research contributions, he won prestigious awards, such as a European Research Council (ERC) Consolidator Grant, the IEEE Robotics and Automation Society Early Career Award, and a Google Research Award. In 2015, he co-founded Zurich-Eye, today Facebook Zurich, which developed the world leading virtual-reality headset: Oculus Quest. Many aspects of his research have been prominently featured in wider media, such as The New York Times, BBC News, Forbes, Discovery Channel.

Friday, September 24, 13:00 – 14:00
Darius Burschka
Technische Universität München, Germany

Challenges in Coupling of Sensor Data to Robot Control at the Example of Camera-based Sense-and-Avoid Systems with Machine Learning and Classical Processing

Many sensor data processing systems exchange the information with control units using three-dimensional representations, which is not native for camera-based systems and, therefore, requires fusion of information from multiple camera images including calibration parameters. This processing step requires additional information about the camera parameters and relative pose of the contributing images and introduces errors that may be critical in low-level protection systems when the calibration parameters change due to vibrations or collisions. The sensor fusion system needs to address three problems to parametrize robot control: the system needs to be able to estimate not only the value but also provide information about the current quality of the estimate, it needs to provide long time convergence to compensate sensor drop-outs due to dynamic light changes, and it needs to provide fast sampling of the environment with low latency and high frame-rate to capture details of the observed motion.

I will present different approaches to address these requirements and discuss the problems with machine learning in control applications. I will present ways, how sensor data can be used directly for control without the necessity of metric reconstruction and motivate a better use of the temporal information in the images for image segmentation and recovery of actions and intentions in the surrounding environment.

Darius Burschka received his PhD degree in Electrical and Computer Engineering in 1998 from the Technische Universität München in the field of vision-based navigation and map generation with binocular stereo systems. Later, he was a Postdoctoral Associate at Yale University, Connecticut, where he worked on laser-based map generation and landmark selection from video images for vision-based navigation systems. From 1999 to 2003, he was an Associate Research Scientist at the Johns Hopkins University, Baltimore, Maryland. From 2003 to 2005, he was an Assistant Research Professor in Computer Science at the Johns Hopkins University. Currently, he is a Professor in Computer Science at the Technische Universität München, Germany, where he heads the Machine Vision and Perception group. He was an area coordinator in the DFG Cluster of Excellence "Cognition in Technical Systems" , he is currently a co-chair of the IEEE RAS Technical Committee on Computer and Robot Vision and Science Board Member of the Munich School of Robotics and Machine Intelligence.
His areas of research are sensor systems for mobile and medical robots and human computer interfaces. The focus of his research is on vision-based navigation and three-dimensional reconstruction from sensor data. He is a Senior Member of IEEE.

Technical Program Overview

September 23	First Conference Day	
	Room A	**Room B**
11:00 – 13:00	**Lunch** *Vogelbräu*	
13:00 - 14:00	**Plenary Talk: Davide Scaramuzza**	
14:00 - 14:30	*Coffee Break*	
14:30 - 15:30	**Robotic Vision and Systems (1)**	**Directional Estimation (1)**
15:30 – 16:00	*Coffee Break*	
16:00 – 17:00	**Robotic Vision and Systems (2)**	**Direction Estimation (2)**
17:00 – 17:30	*Coffee Break*	
17:20 – 18:35	**Tracking**	**Machine Learning**
19:00-22:00	**Welcome Dinner** *Hoepfner Burghof*	

September 24	Second Conference Day	
	Room A	**Room B**
11:00 – 13:00	**Lunch** *Badische Weinstuben*	
13:00 - 14:00	**Plenary Talk:** Darius Burschka	
14:00 - 14:30	*Coffee Break*	
14:30 - 15:45	**Multisensor Systems and Fusion**	**Localization and Navigation**
15:45 – 16:15	*Coffee Break*	
16:15 – 17:30	**Nonlinear Estimation**	**Perception**
17:45-18:15	**Award Ceremony (Room A)**	
19:00-22:00	**Conference Dinner** *Badisch Brauhaus*	

Tutorials

September 25	Tutorials Day	
	Room A	**Room B**
13:00 – 15:30	**An Introduction to Non-linear State Estimation with Discrete Filters** *Felix Govaers*	**From Closed Solutions of Inverse Dynamics to Actual Experimentation with a Trunk-Type Robot** *Renaldas Urniezius*
16:00 – 18:30	**Robust Kalman Filtering** *Florian Pfaff; Benjamin Noack*	**RGB-D Odometry and SLAM** *Javier Civera*
19:00 – 20:00	**Live Q&A Session for Prerecorded Tutorial** **Emergent Universal Turing Machines in Developmental Networks: Vision, Audition, Natural Languages, APFGP and Imitation** *Juyang Weng*	**Live Q&A Session for Prerecorded Tutorial** **Analytic Combinatorics for Multi-Object Tracking** *Roy L. Streit; R. Blair Angle; Murat Efe*

Thursday: 14:30 – 15:30

Sep. 23	Room A	Room B
14:30 - 15:30	**Robotic Vision and Systems (1)** **Chair: Susanne Radtke** **Co-Chair: Benjamin Noack**	**Directional Estimation (1)** **Chair: Florian Pfaff** **Co-Chair: Kailai Li**
14:30	**Latency Analysis of ROS2 Multi-Node Systems.** *Tobias Kronauer; Maximilian Matthe;* *Till Smejkal; Gerhard Fettweis*	**Bingham-Gaussian Distribution on S^3 x R^n for Unscented Attitude Estimation** *Weixin Wang;* *Taeyoung Lee*
14:45	**On-Demand Virtual Highways for Dense UAS Operations.** *Thomas Henderson; David Sacharny;* *Vista Marston*	**Mean Mixtures in Directional Statistics.** *Priyanka Nagar; Andriette Bekker;* *Mohammad Arashi*
15:00	**Skeleton-Based Fall Events Classification with Data Fusion.** *Leiyu Xie; Yuxing Yang;* *Zeyu Fu; Syed Mohsen Naqvi*	**Series Expansion and Pfaffian Systems of the von Mises Distribution on the Torus.** *Kazuya Suzuki;* *Tomonari Sei*
15:15	**Automatic Identification of the Leader in a Swarm using an Optimized Clustering and Probabilistic Approach.** *Ajitesh Singh;* *Panagiotis Artemiadis*	**An Inequality for Bayesian Bregman Risks With Applications in Directional Estimation.** *Michael Fauss; Alex R Dytso;* *H. Vincent Poor*

Thursday: 16:00 – 17:00

Sep. 23	Room A	Room B
16:00 - 17:00	**Robotic Vision and Systems (2)** **Chair: Daniel Clarke** **Co-Chair: Luisa Still**	**Directional Estimation (2)** **Chair: Kailai Li** **Co-Chair: Florian Pfaff**
16:00	**IMU-Based Pose-Estimation for Spherical Robots with Limited Resources.** *Jasper Zevering;* *Anton Bredenbeck*	**Directional DD-Classifiers under Non-Rotational Symmetry.** *Houyem Demni;* *Giovanni Camillo Porzio*
16:15	**Towards Robust VSLAM in Dynamic Environments: A Light Field Approach.** *Pushyami Kaveti; Jagatpreet Singh Nir; Hanumant Singh*	**Conditional Densities and Likelihoods for Densities Based on Trigonometric Polynomials for Hypertori.** *Florian Pfaff; Kailai Li;* *Uwe D. Hanebeck*
16:30	**Robust Multi-Stage Hybrid Vision/Force Control of Industrial Robots.** *Bahar Ahmadi; Wen-Fang Xie;* *Ehsan Mr Zakeri*	**Time-Efficient Bayesian Inference for a (Skewed) von Mises Distribution on the Torus in a Deep Probabilistic Programming Language.** *Ola Rønning; Christophe Ley;* *Kanti V. Mardia; Thomas Hamelryck*
16:45	**Detection of Conductive Lane Markers using mmWave FMCW Automotive Radar.** *Austin Greisman; Keyvan Hashtrudi-Zaad; Joshua Marshall*	**Bayesian Inference for Skew-Wrapped Cauchy Mixture Model using a Modified Gibbs Sampler.** *Najmeh Nakhaeirad; Andriette Bekker;* *Mohammad Arashi*

Thursday: 17:30 – 18:45

Sep. 23	Room A	Room B
17:20 - 18:35	**Tracking** **Chair: Johannes Reuter** **Co-Chair: Antonio Zea**	**Machine Learning** **Chair: Marcel Reith-Braun** **Co-Chair: Marcus Corey**
17:20	**Shape Estimation and Tracking using Spherical Double Fourier Series for Three-Dimensional Range Sensors.** *Tim Baur; Johannes Reuter; Antonio Zea; Uwe Hanebeck*	**A Convolutional Neural Network Combined with a Gaussian Process for Speed Prediction in Traffic Networks.** *Yifei Zhu; Peng Wang; Lyudmila Mihaylova*
17:35	**Incorporating Range-Rate Measurements in EKF-based Elliptical Extended Object Tracking.** *Kolja Thormann; Marcus Baum*	**Generalization Equations for Machine Learners Based on Physical and Abstract Laws.** *Nageswara Rao*
17:50	**Object Detection and Mapping with Bounding Box Constraints.** *Benchun Zhou; Aibo Wang; Jan-Felix Klein*	**CS-Fnet: A Compressive Sampling Frequency Neural Network for Simultaneous Image Compression and Recognition.** *Rui Ma; Qi Hao*
18:05	**Adiabatic Quantum Computing for Solving the Multi-Target Data Association Problem.** *Felix Govaers; Veit Stooß; Martin Ulmke*	**Evaluation of Image Classification Networks on Impulse Sound Classification Task.** *Ravali Nalla; Macarena Varela; Marc Oispuu*
18:20	**Observability-Aware Trajectory Optimization: Theory, Viability & State of the Art.** *Christopher Grebe; Emmett Wise; Jonathan Kelly*	

Friday: 14:30 – 15:45

Sep. 24	Room A	Room B
14:30 - 15:45	**Multisensor Systems and Fusion** **Chair: Susanne Radtke** **Co-Chair: Jiří Ajgl**	**Localization and Navigation** **Chair: Felix Govaers** **Co-Chair: Florian Rosenthal**
14:30	**Lower Bounds in Estimation Fusion With Partial Knowledge of Correlations.** *Jiří Ajgl;* *Ondřej Straka*	**Optimal Sensor Placement for Shooter Localization within a Surveillance Area.** *Luisa Still; Marc Oispuu;* *Wolfgang Koch*
14:45	**Learning and Exploiting Partial Knowledge in Distributed Estimation.** *Susanne Radtke; Jiří Ajgl;* *Ondřej Straka; Uwe D. Hanebeck*	**LiDAR-Aided Relative and Absolute Localization for Automated UAV-based Inspection of Aircraft Fuselages.** *Roland Pugliese*
15:00	**Audio-Video Sensor Fusion for the Detection of Security Critical Events in Public Spaces.** *Michael Hubner; Christoph Wiesmeyr;* *Klaus Dittrich; Bernhard Kohn;* *Heinrich Garn; Martin Litzenberger*	**Robot Localization in a Pipe Network using a Particle Filter with Error Detection and Recovery in a Hybrid Metric-Topological Space.** *Rob Worley;* *Sean Anderson*
15:15	**A Question of Time: Revisiting the Use of Recursive Filtering for Temporal Calibration of Multisensor Systems.** *Jonathan Kelly; Christopher Grebe;* *Matthew Giamou*	**α-Rényi Based Framework for a Robust and Fault-Tolerant Localization.** *Khoder Makkawi; Nesrine Harbaoui;* *Nourdine Ait-Tmazirte;* *Maan El Badaoui El Najjar*
15:30	**Noninvasive Continuous Tracking of Partial Pressure of Oxygen in Arterial Blood: Adapting Microorganisms Bioprocess Soft Sensor Technology for Holistic Analysis of Human Respiratory System.** *Renaldas Urniezius; Donatas Levisauskas;* *Arnas Survyla; Lina Jankauskaite;* *Goda Laucaityte; Dovile Lukminaite;* *Vygandas Vaitkus*	**Navigation of a Self-Driving Vehicle Using One Fiducial Marker.** *Yibo Liu; Hunter Schofield;* *Jinjun Shan*

Friday: 16:15 – 17:30

Sep. 24	Room A	Room B
16:15 - 17:30	**Nonlinear Estimation** **Chair: Felix Govaers** **Co-Chair: Daniel Frisch**	**Perception** **Chair: Antonio Zea** **Co-Chair: Daniel Clarke**
16:15	**Estimation of Wheel Odometry Model Parameters with Improved Gauss-Newton Method.** *Máté Fazekas; Péter Gáspár; Balázs Németh*	**Point Clouds with Color: A Simple Open Library for Matching RGB and Depth Pixels from an Uncalibrated Stereo Pair.** *Jordan R Nowak; Philippe Fraisse; Andrea Cherubini; Jean-Pierre Daures*
16:30	**A Novel Gamma Filter for Positive Parameter Estimation.** *Corey L Marcus; Renato Zanetti*	**Mono-Vision based Moving Object Detection using Semantic-Guided RANSAC.** *Songming Chen; Haixin Sun; Vincent Fremont*
16:45	**UKF Parameter Tuning for Local Variation Smoothing.** *Kristin Nielsen; Caroline Svahn; Hector Rodriguez-Deniz; Gustaf Hendeby*	**Target-Free Extrinsic Calibration of a 3D-Lidar and an IMU.** *Subodh Mishra; Gaurav Pandey; Srikanth Saripalli*
17:00	**Kalman Filtered Compressive Sensing Using Pseudo-Measurements.** *Haibin Zhao; Christopher Funk; Benjamin Noack; Uwe D. Hanebeck; Michael Beigl*	**SemCal: Semantic LiDAR-Camera Calibration using Neural Mutual Information Estimator.** *Peng Jiang; Philip Osteen; Srikanth Saripalli*
17:15	**Gaussian Mixture Estimation from Weighted Samples.** *Daniel Frisch; Uwe Hanebeck*	**Segmentation of Stereo-Camera Depth Image into Planar Regions based on Evolving Principal Component Clustering.** *Miloš Antić; Andrej Zdešar; Igor Skrjanc*

Social Program

Welcome Dinner at Hoepfner Burghof
Thursday, September 23   19:00 – 22:00

In the brewery restaurant our friendly staff will serve you typical dishes of a brewery house, but also of the traditional regional Baden cuisine, in addition to a wide range of regional wines and all beer specialties of the private brewery Hoepfner, the owner of the Hoepfner Burghof since 1899.

Conference Dinner at Badisch Brauhaus
Friday, September 24   19:00 – 22:00

The Badisch Brauhaus is one of the oldest breweries in Karlsruhe. Despite the central location in Karlsruhe's city center, our beer garden is not located on the street in front of the house, as is the case with many other venues, but is located in the beautiful and wonderfully quiet inner courtyard.

Our home-brewed beer is still produced by hand, in contrast to industrially produced brew. Master brewer Peter Kopf and brewer Felix Lang allow the beer the necessary maturing time it needs and leave the natural yeast content exactly where it belongs, in the beer!

This creates the unique taste of the BADISCH HELL and BADISCH DUNKEL as well as the respective seasonal special beers. This was already recognized in 2005 when our BADISCH HELL was awarded the DLG Gold Medal.