Alessandro Fornasier

Control of Networked Systems, University of Klagenfurt (CNS)
B04.2.115 Lakeside Park, B04, level 2, Klagenfurt am Woerthersee, Austria
+43-463-2700-3579
alessandro.fornasier@aau.at

BIOGRAPHY

I am a robotics researcher with an interest in autonomous systems and computer vision. In 2017, I completed my Bachelor's degree in electronic engineering at the University of Udine, Italy.

I participated in a joint study program between the University of Udine, Italy, and the University of Klagenfurt, Austria, where I obtained a Master's double degree in electronic engineering and Information and communication engineering in 2019.

I started my Ph.D. at the University of Klagenfurt in 2020. Under the guidance of professors, Stephan Weiss from the University of Klagenfurt and Robert Mahony from the Australian National University, my research focuses on non-linear and geometric system theory, multi-sensor fusion, and vision-based localization.

During my Ph.D., I had the opportunity to work on exciting research projects. I explored the field of Equivariant estimators, which led to the development of the Equivariant filter for inertial navigation systems. This work has shown promising results and has drawn the attention from the ArduPilot community. Presently, I am leading the efforts to integrate this innovative filter into ArduPilot, a widely adopted open-source autopilot system.

I am also the developer of the MSCEqF, a novel visual-inertial odometry algorithm that combines the idea of the multi-state constraint within the Equivariant Filter framework. Here I was responsible for deriving the necessary theory as well as designing the software architecture and implementing the algorithm.

Throughout my Ph.D., I have been gaining experience in mentoring and supervising master's and Ph.D. students. Moreover, I had the opportunity to participate in European-wide projects such as AMADEE20 and BugWright2.

PERSONAL INFORMATION

Personal Details

- Date of birth: $09 - 25 - 1995$
- Nationality: Italian

Social Media

- Google Scholar.
- ResearchGate.
- Linkedin profile.
- Github profile.
- Personal Website.

Languages

- Italian (Native)
- English (Advanced)
- German (Basic)

ACADEMIC BACKGROUND

Ph.D. Candidate Equivariant Navigation 2020 - Present
University of Klagenfurt, Klagenfurt am Woerthersee, Austria.

- Ph.D. research in equivariant multi-sensor fusion and visual-inertial based navigation under the supervision of prof. Stephan Weiss and prof. Robert Mahony.
- Expected defense: Beginning of 2024.

M.Sc. Information and communication engineering 2019
University of Klagenfurt, Klagenfurt am Woerthersee, Austria.

- Focus areas: Autonomous systems and robotics.
- Master thesis: Group Formulation for Consistent Non-Linear Estimation.
- GPA: 4.0 (converted)

M.Sc. Electronic Engineering 2019
University of Udine, Udine, Italy.

- Focus areas: Electronic Engineering and robotics.
- Master thesis: Group Formulation for Consistent Non-Linear Estimation.
- GPA: 4.0 (converted)

B.Sc. Electronic Engineering 2017
University of Udine, Udine, Italy.

- Focus areas: Electronic Engineering.
- Bachelor thesis: Sviluppo di un'aplicazione web per sistema di domotica basato su local area cloud.
- GPA: 4.0 (converted)

CORE SKILLS

Skills

- STEM (Science, technology, engineering and mathematics)
- Sensor fusion (Kalman filters, observer design, optimization)
- Robotic perception, and Simultaneous Localization and Mapping
- Dynamical system modeling, control, and estimation
- Programming languages (C, C++, Python)
- MATLAB and Python prototyping, and simulations
- Computer vision, and image processing
- Operating systems (Linux)
- Version control (GIT)

PROJECTS

Equivariant Filter Design for the ArduPilot Autopilot System *2023 - Present*

This project seeks to integrate the most recent advancements in equivariant filtering for inertial navigation systems into the widely-used ArduPilot open-source autopilot system. This project aims to enhance the accuracy, robustness, and reliability of autonomous navigation for aerial vehicles and ground-based robotics.

MEDuSe: Modular Environment-Aware Dynamic Multi-Sensor Fusion for Robust Navigation of SWAP-Constrained Autonomous Systems 2022 - Present

The MEDuSe project focuses on the application of Equivariant Filter design principles to the Visual-Inertial Odometry (VIO) problem. The project aims to enhance the accuracy, efficiency, and robustness of VIO algorithms by leveraging the power of symmetries. Visual-Inertial Odometry is a challenging problem due to the inherent unobservability of the global position and yaw. Traditional VIO algorithms use standard filters, such as the Extended Kalman Filter (EKF), to estimate the robot's pose. However, these filters are not designed to handle the complex geometries that arise in the VIO problem, and suffer from inconsistencies. Equivariant filters, on the other hand, are specifically designed to handle and exploit the complex symmetries that arise in robotics problems.

The MEDuSe project involves evaluating the feasibility, deriving the mathematical and theoretical foundations, and developing a novel Equivariant Filter based framework for the VIO problem. The outcome of the MEDuSe project will be a state-of-the-art VIO algorithm that is more accurate, efficient and robust than existing algorithms. The algorithm will have significant applications in robotics, including autonomous vehicles, drones, and mobile robots.

MSPFCI: Multiwii Serial Protocol Flight Controller Interface 2022 - Present

As a personal project undertaken during my free time, I am dedicated to creating a Multiwii Serial Protocol Interface (MSPFCI) tailored specifically for flight controllers running Cleanflight/Betaflight/Inav. The primary goal of MSPFCI is to grant users complete control over their flight controllers while seamlessly integrating with ROS (Robot Operating System). [Code]

Equivariant Filter Design for Inertial Navigation Systems with Input Measurement Biases 2020 - 2022

The goal of this cutting-edge research is to find a symmetry for the inertial navigation problem while considering inertial measurement unit biases explicitly. By defining the system on a homogenous space and identifying a suitable symmetry group, we can leverage the robustness of the Equivariant Filter framework to design estimators that outperform existing solutions.

The project involves deriving a novel theory for inertial navigation systems within the context of equivariant systems and implementing an Equivariant filter tailored for navigation problems. This work is expected to advance the field of inertial navigation and contribute to more accurate and reliable autonomous systems.

Autonomous Robotic Inspection and Maintenance on Ship Hulls and Storage Tanks 2020 - 2022

Underwater hull cleaning is an important part of ship maintenance, which in-

cludes all techniques used to keep the part of the ship under the waterline in good condition. The EU-funded BugWright2 project will develop and demonstrate an adaptable autonomous robotic solution for servicing the outer hulls of ships. It will combine the survey capabilities of autonomous micro air vehicles (MAV) and small autonomous underwater vehicles (AUV) with teams of magnetic-wheeled crawlers operating directly on the surface of the structure. The project will facilitate a multi-robot visual and acoustic inspection, detecting corrosion patches or cleaning the surface as necessary. What is more, the technology being developed may also be adapted to storage tanks or other structures assembled out of metal plates.

As part of the BugWright2 project, I have designed and developed a multi-sensor navigation algorithm based on the Multi State Constraint Kalman FIlter (MSCKF) framework for robot localization. This framework allows tight fusion of imu, camera, gnss, uwb, pressure, and laser range information.

AMADEE-20: Autonomous Mars-Analog Zone Exploration 2020 - 2021

Navigating with the eyes of a camera: How can helicopters navigate on Mars? Machines usually use navigation systems such as GPS to locate themselves in outdoor areas. However, other planets do not have such a system yet. The project AMAZE aims to answer this question. The core of the AMAZE project within the Analog Mars mission AMADEE-20, which is led by the Austrian space agency (OEWF), is the camera-based navigation. For this, a helicopter is equipped with a camera that serves the same purpose as the human eye. The camera is used to visually detect the environment, sense obstacles, and allow safe navigation in the surrounding area.

Within the AMAZE project, my responsibilities spanned multiple domains. In addition to serving as the project's Co-Investigator, I have also lead the design and development of an autonomy engine for the helicopter utilized in the project's mission.

Finger Veins Based Recognition System 2019

This project was undertaken for the pervasive computing course at the University of Klagenfurt, designed for M.Sc. students in information and communication engineering, as well as Ph.D. students. The project's main focus was to create an Image processing-based finger veins recognition system, tailored for smart home applications. [Code Python] [Code MATLAB]

Sniper Remote Scope 2018

Sniper Remote Scope is a project developed for the ICT laboratory course, as part of the Master's degree in electronic engineering at the University of Udine. The project's objective is to create a vision-based digital rifle scope that offers an augmented reality service to aid shooters in low-visibility target situations.

Simple MIPS pipelined datapath with data hazard solution and 2 level cache memory VHDL Implementation 2017

This project was a component of the digital system electronics course offered to Master's students at the University of Udine. The objective of the project was to develop a VHDL implementation of a MIPS pipelined datapath, equipped with a data hazard solution and a 2-level cache memory system. [Code]

PERSONAL ACHIEVEMENTS

Awards and Distinctions

- *University of Udine best 2019/2020 postgraduate award in electronic engineering*, University of Udine, 2020

PUBLICATIONS

Selected Conference and Journals Publications
A complete list is available on my google scholar page.

12. A. Fornasier, Y. Ge, P. van Goor, R. Mahony, and S. weiss, "Equivariant Symmetries for Inertial Navigation Systems", submitted to Automatica, 2023. [ArXiv]
11. G. Delama, F. Shamsfakhr, S. Weiss, D. Fontanelli, and A. Fornasier, "UVIO: An UWB-Aided Visual-Inertial Odometry Framework with Bias-Compensated Anchors Initialization", in 2023 IEEE International Conference on Intelligent Robots and Systems (IROS), 2023.
10. A. Fornasier, Y. Ng, R. Mahony, and S. Weiss, "Equivariant filter design for inertial navigation systems with input measurement biases", in 2022 IEEE International Conference on Robotics and Automation (ICRA), 2022. [IEEExplorer]
9. A. Fornasier, Y. Ng, C. Brommer, C. Böhm, R. Mahony, and S. Weiss, "Overcoming Bias: Equivariant Filter Design for Biased Attitude Estimation with Online Calibration", in 2022 IEEE Robotics and Automation Letters (RA-L), 2022. [IEEExplore] [Code]
8. A. Fornasier, M. Scheiber, A. Hardt-Stremayr, R. Jung, and S. Weiss, "VINSEval: Evaluation Framework for Unified Testing of Consistency and Robustness of Visual-Inertial Navigation System Algorithms", in 2021 IEEE International Conference on Robotics and Automation (ICRA), 2021. [IEEExplore]
7. M. Scheiber, A. Fornasier, R. Jung, C. Böhm, R. Dhakate, C. Stewart, S. Weiss, and C. Brommer, "CNS Flight Stack for Reproducible, Customizable, and Fully Autonomous Applications", in 2022 IEEE Robotics and Automation Letters (RA-L), 2022. [IEEExplore] [Code]
6. C. Brommer, A. Fornasier, M. Scheiber, J. Delaune, R. Brockers, J. Steinbrener, and S. Weiss, "INSANE: Cross-Domain UAV Data Sets with Increased Number of Sensors for developing Advanced and Novel Estimators", Submitted in the International Journal of Robotics Research (IJRR), 2022. [Preprint]
5. J. Steinbrener, C. Brommer, T. Jantos, A. Fornasier, and S. Weiss, "Improved State Propagation through AI-based Pre-processing and Downsampling of High-Speed Inertial Data", in 2022 IEEE International Conference on Robotics and Automation (ICRA), 2022. [IEEExplore]
4. J. Michalczyk, C. Schöffmann, A. Fornasier, J. Steinbrener, and S. Weiss, "Radar-Inertial State-Estimation for UAV Motion in Highly Agile Manoeuvres", in 2022 IEEE International Conference on Unmanned Aircraft Systems (ICUAS), 2022. [IEEExplore]
3. B. Starbuck, A. Fornasier, S. Weiss, and C. Pradalier, "Consistent State Estimation on Manifolds for Autonomous Metal Structure Inspection", in 2021 IEEE International Conference on Robotics and Automation (ICRA), 2021. [IEEExplore]
2. J. Blueml, A. Fornasier, and S. Weiss, "Bias Compensated UWB Anchor Initialization using Information-Theoretic Supported Triangulation Points", in 2021 IEEE International Conference on Robotics and Automation (ICRA), 2021. [IEEExplore]

1. E. Allak, A. Fornasier, and S. Weiss, "Consistent Covariance Pre-Integration for Invariant Filters with Delayed Measurements", in 2020 IEEE International Conference on Intelligent Robots and Systems (IROS), 2020. [IEEExplore]

STUDENT SUPERVISION

2. Julian Blueml, *Bias Compensated UWB Anchor Initialization using Information-Theoretic Supported Triangulation Points*, M.Sc. thesis, 2020

1. Giulio Delama, Farhad Shamsfakhr, *UVIO: An UWB-Aided Visual-Inertial Odometry Framework with Bias-Compensated Anchors Initialization*, to appear in 2023 IEEE International Conference on Intelligent Robots and Systems (IROS), 2023.