Alessandro Fornasier

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BIOGRAPHY

I have obtained my Bachelor's degree in electronic engineering from University of Udine, Italy in 2017. In 2019, I obtained my Master's double degree in electronic engineering, and Information and communication engineering from a joint study at the University of Udine, Italy, and the University of Klagenfurt, Austria. Since 2020 I am a Ph.D. candidate at the University of Klagenfurt under the supervision of Professor Stephan Weiss from University of Klagenfurt, and professor Robert Mahony from Australian National University. My research interests are in non-linear and geometric system theory, multi-sensor fusion, and vision based localization with applications in mobile robotics and computer vision.

PERSONAL INFORMATION

Personal Details

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

Social Media

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

Languages

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

CORE SKILLS

Skills

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

PROJECTS

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

While sensor fusion for state estimation on mobile platforms has a long history, recent issues particularly concerning the availability of communication and GNSS signals clearly demonstrate the limited robustness and resilience of current methods in contested environments. The addition of sensor modalities mitigates failure modes of individual sensors, but quickly scales up both the computational and operational complexity of the overall estimation framework.

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 Protocl Flight Controller Interface 2022 - Present

This free-time project consists of the development of a multiwii serial protocol interface for flight controllers running Cleanflight/Betaflight/Inav. MSPFCI will allow full control over your flight controller, and full integration with ROS (Robot Operating System). [Code]

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

Inertial Navigation Systems (INS) are a key technology for autonomous vehicles applications. Recent advances in estimation and filter design for the INS problem have exploited geometry and symmetry to overcome limitations of the classical Extended Kalman Filter (EKF) approach that formed the mainstay of INS systems since the mid-twentieth century. In this project, the recently proposed Equivariant Filter (EqF) framework is exploited to derive, design, and implement novel observers for biased inertial-based navigation.

This is a cutting-edge research project with the goal of finding a symmetry for the inertial naviagation problem when Inertial Measurement Units biases are explicitly considered in the problem formulation. By defining the system on a homogenous space and determining a symmetry group acting on such space the performance, and robustness of the Equivariant Filter framework can be exploited to design estimators that outperforms state-of-the-art solutions.

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

Underwater hull cleaning is an important part of ship maintenance, which includes 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.

Within 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 spread across multiple domains, while being the project's Co-Investigator, I have also designed and developed the autonomy engine of the helicopter used in the project's mission.

Finger Veins Based Recognition System 2019

This project was developed for the course Pervasive computing held at the University of Klagenfurt for M.Sc. students in information and communication engineering and for Ph.D students. The project consists on a Image processing based finger veins recognition system for smart home applications. [Code Python] [Code MATLAB]

Sniper Remote Scope 2018

Sniper Remote Scope is a project developed for the ICT laboratory course, held by professor Riccardo Bernardini, as part of the Master degree in electronic engineering at University of Udine. The aim of the whole project is to build a vision based digital rifle scope able to provide an augmented reality service helping the shooter in all the situations in which the visibility of the target is low.

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

Simple VHDL implementation of a MIPS pipelined datapath with data hazard solution and 2 level cache memory for the course of Digital System Electronics held by prof. Antonio Abramo for M.Sc. students of electronic engineering at the University of Udine. [Code]

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.

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)

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.

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

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