

Piergiuseppe Mallozzi

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Software Engineering/Architecture | Formal Methods | AI/ML/DL | Zero-Knowledge Proof

Experienced computer scientist and software engineer with comprehensive expertise in system design and integration. Combining a solid theoretical foundation with hands-on experience, I specialize in architecting, modeling, and verifying complex software systems, utilizing both formal verification and data-driven approaches.

Current Position

Postdoctoral Researcher in EECS
UC BERKELEY

Berkeley, USA

Sept. 2021 - present

- Led the development of *Configurable Neural Networks with Biochemically-Informed Data Generation*, a TensorFlow-based framework for neural networks. This project features customizable neural network designs, dynamic synthetic data generation using biochemical models, and seamless integration with high-performance computing systems.
- Architected and implemented a robust *Zero-Knowledge Proof (ZKP)* framework to verify statements on sensitive real-world data, utilizing blockchain technology as a publicly auditable infrastructure.
- Utilizing artificial intelligence to develop correct-by-construction designs, with focus on air vehicles (UAVs) and robotic missions.
- Contributing to the development of PACTI, a specification-based *system analysis and design tool* that is being tested by multiple organizations, including NASA.
- Contributed as a key member of the research and development team for the DARPA project "*Symbiotic Design for Cyber-Physical Systems*", where I developed AI-based approaches to facilitate the correct-by-construction design of Cyber-Physical Systems.

Education

PhD in Electrical Engineering and Computer Science
CHALMERS UNIVERSITY OF TECHNOLOGY

Göteborg, Sweden

2016-2021

Thesis: "Designing Trustworthy Autonomous Systems"

- Designed and implemented a novel framework for autonomous systems design using *assume-guarantee contracts* to model requirements and system components, ensuring consistency and completeness in system specifications. Developed new algorithms to maximize reuse of existing components and efficiently realize robotic missions, reducing design complexity.
- Applied *formal methods*, including model checking, run-time monitoring and reactive synthesis, to ensure trustworthiness of autonomous systems in different contexts, such as vehicle platooning, reward hacking prevention, safe reinforcement learning and requirement engineering.

BSc and MSc in Computer Engineering Graduated with highest honors, score of 110/110
UNIVERSITY OF PISA

Pisa, Italy

2009-2016

Thesis: "Design and development of a co-simulation library for the PVSio-web prototyping tool"

- Designed and developed a set of libraries for the *co-simulation* of Cyber-Physical Systems.
- Completed in collaboration with *NASA Langley Research Center*, Virginia, USA.
- Developed a library that forms a core part of the co-simulation engine. The library is responsible for coordinating and controlling different models, each developed in their own environment (e.g., Java, PVS, C, Matlab Simulink).

Skills

Programming: Python, C/C++, JAVA, HTML/CSS/Javascript, Flask/React/NextJS, MySQL, Matlab, LaTeX, Docker, Git **Software Engineering:** Requirement Engineering, Object-Oriented Programming, Design Patterns, Software Architecture, Agile Development, Testing, Debugging, Version Control, DevOps (CI/CD), Microservices Architecture, Back-end and Front-end Technologies. **Formal Methods:** Linear Temporal Logic, Model Checking, Reactive Synthesis, Runtime Verification. **Theory of Computation:** Automata and Languages, Computability, Complexity Theory, Turing Machines, Formal Language Theory, Algorithm Analysis. **Algorithms and Data Structures:** Operations Research, Graph Theory, Optimization. **Cyber-Physical Systems and Embedded Systems:** Electronics, Logic Circuits, Computer Architecture, Concurrent and Distributed Systems. **Machine Learning:** Supervised Learning, Unsupervised Learning, Deep Learning, Neural Networks, Natural Language Processing, Computer Vision. **Security and Blockchain:** Advanced Networking, Internet Protocols, Cryptography, Network Security, Blockchain Technology, Zero-Knowledge Proof. **Hardware Engineering:** RTL Design, Hardware Description Languages, Digital Logic Design, Microcontrollers, ASIC/FPGA, CMOS Technology. **Database Management:** SQL, NoSQL (e.g., MongoDB), Database Design and Optimization. **Languages:** Italian (Native), English (Full Professional Proficiency), French (Good), Spanish (Intermediate)

Awards

Zero-Knowledge Proof Hackathon 2023 - First Prize

Berkeley, USA

THREE MONTHS PROJECT WORLD-WIDE COMPETITION, 600 PARTICIPANTS AND 150 TEAMS

2023

- Led winning project *Fact Fortress*, securing first prize at the UC Berkeley ZKP Hackathon 2023 Application Track.

Knut and Alice Foundation Fellow

Sweden and USA

FUNDED RESEARCH VISIT

2019

- Gained expertise in Deep Learning, Formal Methods and Contract-Based Design.

IDEA League Scholarship

Europe

FUNDED A DOCTORAL SCHOOL ACROSS TOP EUROPEAN UNIVERSITIES

2017 and 2018

- Developed a strong network with ETH Zurich, TUDelft, Politecnico di Milano

Japanese Society for Promoting Science (JSPS) Fellowship

Tokyo, Japan

WASEDA UNIVERSITY

2018

- Collaborated with top Japanese research institutions as an awarded candidate among applicants from around the world.

Wallenberg AI, Autonomous Systems and Software Program

Sweden

FELLOWSHIP FROM THE LARGEST INDIVIDUAL RESEARCH PROGRAM IN SWEDEN

2016-2021

- Awarded travel grants to present research at top academic and industry research centers worldwide, including Airbus (France), German Aerospace Center DLR (Germany), Stanford, UC Berkeley, Google, and Netflix (USA), and NTU, SUTD (Singapore).

NASA Langley Research Center Summer Program

Virginia, USA

FUNDED INTERNSHIP

2015

- Led the design and development of a flight simulator showcasing NASA Langley's NextGen collision avoidance system (DAIDALUS), incorporating PVS verification for mathematical model execution.

Queen Mary University of London

London, UK

FUNDED TRAINEESHIP PROGRAM

2015

- Created a communication middleware enabling co-simulation of device prototypes, utilized to develop an Integrated Clinical Environment with interoperable medical devices in the CHI+MED research team.

Scholarships for studying abroad

Europe

FUNDED BY THE EUROPEAN UNION

2012-2015

- Enrolled in study programs in Paris, Copenhagen, and Madrid, earning additional credit beyond the standard CS curriculum.

Some Open-Source Projects

For additional projects and access to source code, please visit my website: <https://pierg.github.io/projects>

Biochemically-Informed Neural Networks

Berkeley, USA

[HTTPS://GITHUB.COM/PIERG/NEURAL_NETWORKS/](https://github.com/pierg/neural_networks/)

2023

- Led the development of a TensorFlow-based framework for neural networks, focusing on *customizability* and *dynamic synthetic data generation*.
- Integrated advanced *biochemical models* such as Michaelis-Menten kinetics for data simulation, enhancing the framework's applicability in scientific research.
- Implemented *high-performance computing* compatibility, for efficient, scalable distributed training.

Fact Fortress

Berkeley, USA

[HTTPS://PIERG.GITHUB.IO/FACT-FORTRESS-WEB/](https://pierg.github.io/fact-fortress-web/)

2023

- Leading and making significant contributions to the development of Fact Fortress, an on-chain Zero-Knowledge Proof framework.
- We use Zero-Knowledge Proofs (ZKP) for trustworthy and private fact-checking leveraging on proof of data provenance, auditable data-access policies and democratizing the construction of ZKP circuits.

PACTI

Berkeley, USA

[HTTPS://WWW.PACTI.ORG](https://www.pacti.org)

2021-2023

- Contributed to the development and maintenance of PACTI, an open-source tool designed for scalable system analysis and design. PACTI utilizes an Assume-Guarantee contracts framework, incorporating support for polyhedral constraints and ongoing enhancements for Linear Temporal Logic.
- Developed a case study on UAV topology using contract-based design to enforce the rules of a context-free grammar that defines the feasible space of UAV topologies.

- Architected and led the development of a robust software pipeline for the design and evaluation of unmanned aerial vehicles (UAVs) in the context of a DARPA challenge. This involved integrating multiple software modules and connecting it to a pipeline of evaluation. While I was instrumental in producing most of the codebase, the emphasis was on quality and integration rather than quantity.
- Key architectural and functional features of the software pipeline include:
 - A cohesive integration of different modules, emphasizing software architecture best practices.
 - Context-sensitive grammar for generating abstract UAV topologies, ensuring flexibility and adaptability in design.
 - User-centric JSON and GUI interfaces, facilitating designers in expressing their preferences across varying abstraction levels.
 - Efficient transition from abstract topologies to tangible UAV component graphs, optimizing component selection from a comprehensive UAV library.
 - Insightful learning of prevalent structures from pre-existing UAV designs using graph isomorphism analysis.
 - Parameters and control optimization using techniques like Simulated Annealing and Bayesian optimization.

CROME - Contract-Based Goal Graph Analysis Tool

[HTTPS://GITHUB.COM/PIERG/CROME-CGG](https://github.com/PIERG/CROME-CGG)

Berkeley, USA

2019-2021

- Developed a tool for modeling and deploying robotic missions using contract-based goal graph analysis.
- Facilitated mission design with Linear Temporal Logic (LTL) or Specification Patterns.
- Conducted efficient goal analysis through the CGG, a graph with algebraically-combined contract nodes.
- Supported mission simulation, guiding robots under various environments using orchestrated controllers.
- Integrated an LTL formula manipulation library and parallel reactive synthesis for enhanced mission realization.

Teaching Activity

Machine Learning and Software Engineering for AI Systems

COURSE DEVELOPER AND LECTURER

Chalmers University of Technology

fall19, summer20, fall20

- Created a course that provided a strong theoretical and mathematical foundation for Machine Learning and Deep Learning, while also offering practical applications and industry use cases.)
- Covered a wide range of topics including supervised learning (linear and polynomial regression, logistic regression, decision trees, gradient descent), unsupervised learning (clustering, K-means), reinforcement learning (MDP, value iteration, Q-learning), deep neural networks (convolutional neural networks, recurrent neural networks), and practical implementation using Python.

Advanced Software Architecture

TEACHING ASSISTANT AND LECTURER

Chalmers University of Technology

spring16, spring17, spring18

- Covered various topics, including Architectural Styles, Patterns, and Tactics, as well as Domain-Specific Software Architectures.
- Explored the phenomenon of Software Architecture Decay and its implications on large-scale software systems.

Model-Based Software Development

TEACHING ASSISTANT AND LECTURER

Chalmers University of Technology

fall16, fall17, fall18

- Covered topics including topics such as Domain Models, Use Case, Activity, Class, Component, Sequence, Deployment Diagrams, and State Machines, using modeling languages such as UML and SysML.
- Coordinated and supervised student groups working on a large-scale software development project for the course.

Publications

Pacti: Scaling Assume-Guarantee Reasoning for System Analysis and Design

Inigo Incer, Apurva Badithela, Josefine Graebener, **Piergiuseppe Mallozzi**, Ayush Pandey, Sheng-Jung Yu, Albert Benveniste, Benoit Caillaud, Richard Murray, Alberto Sangiovanni-Vincentelli, Sanjit Seshia

under review, 2023

Deploying ZKP Frameworks with Real-World Data: Challenges and Proposed Solutions

Piergiuseppe Mallozzi

under review, 2023

Contract-Based Specification Refinement and Repair for Mission Planning

Piergiuseppe Mallozzi, Inigo Incer, Pierluigi Nuzzo, Alberto Sangiovanni-Vincentelli

International Conference of Formal Methods in Software Engineering (FORMALISE), 2023

A Framework for Specifying and Realizing Correct-by-Construction Contextual Robotic Missions Using Contracts

Piergiuseppe Mallozzi, Pierluigi Nuzzo, Nir Piterman, Patrizio Pelliccione, Gerardo Schneider

under review, 2023

A grammar for the representation of Unmanned Aerial Vehicles with 3D topologies

Piergiuseppe Mallozzi, Hussin Sibai, Inigo Pandey, Alberto Sangiovanni-Vincentelli, Sanjit Seshia

under review, 2023

Incremental Refinement of Goal Models with Contracts

Piergiuseppe Mallozzi, Pierluigi Nuzzo, Patrizio Pelliccione

Fundamentals of Software Engineering (FSEN), 2021

CROME: Contract-Based Robotic Mission Specification

Piergiuseppe Mallozzi, Pierluigi Nuzzo, Patrizio Pelliccione, Gerardo Schneider

International Conference on Formal Methods and Models for System Design (MEMOCODE), 2020

- A Runtime Monitoring Framework to Enforce Invariants on Reinforcement Learning Agents Exploring Complex Environments
Piergiuseppe Mallozzi, Ezequiel Castellano, Patrizio Pelliccione, Gerardo Schneider, Kenji Tei
Robotics Software Engineering (RoSE), Co-located with ICSE, 2019
- Autonomous Vehicles: State of the Art, Future Trends, and Challenges
Piergiuseppe Mallozzi, Patrizio Pelliccione, Alessia Knauss, Christian Berger, Nassar Mohammadiha
Book Chapter in Automotive Systems and Software Engineering, 2019
- Engineering Trustworthy Self-Adaptive Autonomous Systems
Piergiuseppe Mallozzi
Licentiate Thesis, 2018
- MoVEMo: a Structured Approach for Engineering Reward Functions
Piergiuseppe Mallozzi, Raúl Pardo, Vincent Duplessis, Patrizio Pelliccione, Gerardo Schneider
IEEE International Conference on Robotic Computing (IRC), 2018
- Keeping Intelligence Under Control
Piergiuseppe Mallozzi, Patrizio Pelliccione, Claudio Menghi
Software Engineering for Cognitive Services (SE4COG), Co-located with ICSE, 2018
- Combining Machine-learning with Invariants Assurance Techniques for Autonomous Systems
Piergiuseppe Mallozzi
Symposium at International Conference on Software Engineering (ICSE), 2017
- Automotive Architecture Framework: The Experience of Volvo Cars
 Patrizio Pelliccione, Eric Knauss, Rogardt Heldal, S Magnus Ågren, **Piergiuseppe Mallozzi**, Anders Alminger, Daniel Borgentun
Journal of Systems Architecture, 2017
- Formal Verification of the on-the-fly Vehicle Platooning Protocol
Piergiuseppe Mallozzi, Massimo Sciancalepore, Patrizio Pelliccione
Software Engineering for Resilient Systems (SERENE), 2016
- A Proposal for an Automotive Architecture Framework for Volvo Cars
 Patrizio Pelliccione, Eric Knauss, Rogardt Heldal, Magnus Ågren, **Piergiuseppe Mallozzi**, Anders Alminger, Daniel Borgentun
Automotive Systems/Software Architectures (WASA), 2016
- PVSio-web: Mathematically Based Tool Support for the Design of Interactive and Interoperable Medical Systems
 Paul Curzon, Paolo Masci, Patrick Oladimeji, **Piergiuseppe Mallozzi**
EAI Endorsed Transactions on Collaborative Computing. ACM, 2015
- Design and Development of a Co-simulation Library for the PVSio-web Prototyping Tool
Piergiuseppe Mallozzi
Master Thesis, 2015
- Using PVSio-web and SAPERE for Rapid Prototyping of User Interfaces in Integrated Clinical Environments
 Paolo Masci, **Piergiuseppe Mallozzi**, Francesco Luca De Angelis, G Di Marzo Serugendo, Paul Curzon
Verification and Assurance (VERISURE), Co-located with CAV, 2015

Some Invited Talks

2022	DARPA PI Meeting , Contract-Based Symbiotic Design for Cyber-Physical Systems	Seattle, USA
2019	Nanyang Technological University (NTU) , Hierarchical Refinement of Goal Models using Contracts	Singapore
2019	Singapore University of Technology and Design (SUTD) , Goal Models and Contract-Based Design	Singapore
2018	Japanese Society for Promoting Science (JSPS) , STINT Sweden Representative Talk	Tokyo, Japan
2018	Okinawa Institute of Science and Technology (OIST) , Safe Reinforcement Learning	Okinawa, Japan
2018	Osaka University , Run-time Monitoring and Reinforcement Learning	Osaka, Japan
2018	Kyoto University , Run-time Monitoring and Reinforcement Learning	Kyoto, Japan
2018	Advanced Telecommunications Research Institute (ATR) , Safe Reinforcement Learning	Kyoto, Japan
2017	Cruise , Autonomous Driving and Reinforcement Learning	San Francisco, USA
2017	Ericsson , Thrustworthy Autonomous Systems	Santa Clara, USA
2017	International Conference of Software Engineering (ICSE) , Self-Adaptive Systems	Buenos Aires, ARG
2015	NASA Langley Research Center , Flight Simulator Demonstration and Formal Verification	Langley, USA

References

Alberto Sangiovanni-Vincentelli	Supervisor at UC-Berkeley	alberto@berkeley.edu
Pierluigi Nuzzo	Assistant Professor at USC-Viterbi	nuzzo@usc.edu

Additional references available upon request.