Piergiuseppe **Mallozzi**

Berkeley (CA), USA

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Software Engineering | System Modeling and Analysis | Formal Methods | AI/ML/DL

Experienced computer scientist and engineer with a broad background in both hardware and software. Combining a solid theoretical foundation with practical expertise, applying formal verification and data-driven methods to analyze, model, and verify complex systems effectively.

Current Position

Postdoctoral Researcher in EECS   *Berkeley, USA*
UC Berkeley   *Sept. 2021 - present*

- 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   *Göteborg, Sweden*
Chalmers University of Technology   *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   *Pisa, Italy*
University of Pisa   *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, HTML/CSS/Javascript, Flask/React/NextJS, JAVA, C/C++, 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
Three months project world-wide competition, 600 participants and 150 teams

Berkeley, USA
2023

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

Knut and Alice Foundation Fellow
Funded research visit

Sweden and USA
2019

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

IDEA League Scholarship
Funded a doctoral school across top European universities

Europe
2017 and 2018

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

Japanese Society for Promoting Science (JSPS) Fellowship
Waseda University

Tokyo, Japan
2018

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

Wallenberg AI, Autonomous Systems and Software Program
Fellowship from the largest individual research program in Sweden

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
Funded internship

Virginia, USA
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
Funded traineeship program

London, UK
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
Funded by the European Union

Europe
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`

Fact Fortress
`https://pierg.github.io/fact-fortress-web/`

Berkeley, USA
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
`https://www.pacti.org`

Berkeley, USA
2021-2023

- Contributed to the 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.

Berkeley CPS Symbiotic Design *Berkeley, USA*
2021-2022

- Led the development of a comprehensive software pipeline for designing and evaluating unmanned aerial vehicles (UAVs) in the context of a DARPA challenge, contributing over 100,000 lines of code.
- Key features of the software pipeline include:
    - Context-sensitive grammar for generating abstract UAV topologies.
    - User-friendly JSON and GUI interfaces enabling designers to express preferences at multiple levels of abstraction.
    - Refinement from abstract topologies to graphs of UAV components and connectors, with optimization of component selection from a library of real UAV components.
    - Learning of common structures from existing UAV designs through graph isomorphism analysis.
    - Parameters and control optimization using Bayesian optimization techniques.

CROME - Contract-Based Goal Graph Analysis Tool *Berkeley, USA*
2019-2021

- Contract-based goal graph analysis tool for modeling and deploying robotic missions in complex environments.
- Enabled designers to use Linear Temporal Logic (LTL) or Specification Patterns to model the environment and goals of robotic missions.
- Implemented efficient goal analysis via the construction of the CGG, a graph of contracts where each node is combined with algebraic operations.
- Enabled simulation of robotic missions through realization, execution, and orchestration of different controllers that guide the robot under varying environmental contexts.
- Implemented an LTL formulas manipulation library and parallel reactive synthesis controllers for more efficient realization of robotic missions.

Teaching Activity

Machine Learning and Software Engineering for AI Systems *Chalmers University of Technology*
MAIN COURSE DEVELOPER AND LECTURER *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 *Chalmers University of Technology*
TEACHING ASSISTANT AND LECTURER *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 *Chalmers University of Technology*
TEACHING ASSISTANT AND LECTURER *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
International Workshop on 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
International Workshop on Software Engineering for Cognitive Services (SE4COG), Co-located with ICSE, 2018

Combining Machine-learning with Invariants Assurance Techniques for Autonomous Systems
Piergiuseppe Mallozzi
Doctoral 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
International Workshop on 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
Workshop on 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
Verisure2015, Workshop on Verification and Assurance, 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 Scince (JSPS)**, STINT Sweden Reppresentative 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.