Martina Lippi

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Date of birth: 23 October 1992
Nationality: Italian

CURRENT POSITION

PhD Student in Information Engineering at the University of Salerno, Italy

EDUCATION

PhD Degree in Information Engineering Nov. 2017 - Present
University of Salerno, Fisciano (SA), Italy

- **Research topics:** the research activity concerns the distributed control of multi-robot systems that may operate in the presence and/or collaboration of human operators; it is under the supervision of Prof. Alessandro Marino and Prof. Pasquale Chiacchio
- **Exams:** academic writing and publishing, patents and startups, funding and management of research projects, English, natural computing, numerical signal processing, industrial information systems

Visiting PhD Student in Information Engineering Feb. 2020 - Mar. 2020
University of Cassino and Southern Lazio, Cassino (FR), Italy

- **Research topics:** the research activity focuses on recognizing and classifying forces that a manipulator exchanges with the environment and finally on reacting accordingly

Visiting PhD Student in Information Engineering Apr. 2019 - Dec. 2019
KTH Royal Institute of Technology, Stockholm, Sweden

- **Research topics:** the research activity focused on multi-manipulator systems aimed at co-manipulating deformable objects; it was under the supervision of Prof. Danica Kragic and included the collaboration with the group lead by Prof. Carme Torras at UPC Universitat Politècnica de Catalunya, Barcelona, Spain

Master's Degree in Computer Engineering Jan. 2015 - Feb. 2017
University of Salerno, Fisciano (SA), Italy

- **Final Mark:** 110/110 cum laude
- **Thesis:** *Decentralized control of cooperative mobile manipulators: synthesis and experiments*, Supervisors: Prof. Alessandro Marino, Prof. Pasquale Chiacchio
- **Exams:** software engineering, advanced programming techniques, advanced automatic controls, information coding and compression, embedded systems, computer architectures, automation and robotics, distributed programming, computer network security, semantic technologies for enterprise systems, artificial intelligence, telecommunication networks, model and systems for artificial vision

Bachelor's Degree in Computer Engineering Oct. 2011 - Dec. 2014
University of Salerno, Fisciano (SA), Italy

- **Final Mark:** 110/110 cum laude
- **Thesis:** *Design, implementation and performance comparison of three algorithms based on artificial vision for people counting*, Supervisors: Prof. Mario Vento, Prof. Alessia Saggese
- **Exams:** mathematics I, mathematics II, mathematics III, physics, logic networks, programming fundamentals, algorithms and data structures, computer organization, electrotechnics, fundamentals of automatic control, signal theory, databases, objected oriented programming, computer networks: architectures and services, antenna and wireless links, software tecnologies for the WEB, computer technologies for automatic control, theory and techniques of telecommunications, digital circuits, operative systems

Scientific High School Degree Sep. 2006 - Jul. 2011

Scientific High School "G. Da Procida", Salerno (SA), Italy

- **Final Mark:** 100/100

PROFESSIONAL EXPERIENCE

Scolarship in Robotics May 2017 - Oct. 2017

University of Salerno, Fisciano (SA), Italy

- **Activity:** design and development of control algorithms for the decentralized control of cooperative manipulators and testing on a work-cell composed of 2 Comau SmartSix equipped with C4G controllers (Real-time Linux OS and OROCOS framework)

Internship in Artificial Vision Aug. 2014 - Oct. 2014

A.I. Tech s.r.l, Fisciano (SA), Italy

- **Activity:** design and development of an application for people counting based on video analysis techniques. In particular, the video stream is acquired by means of a fixed camera placed in vertical position with respect to the area to be monitored and 3 algorithms for detection and tracking people have been devised and tested

TRAINING EXPERIENCE

Model Predictive Control Course organized by IMT Lucca Jun. 2020

Czech Technical University, Prague, Czech Republic

- **Topics:** General concepts of Model Predictive Control were introduced as well as linear time-varying, non linear, hybrid, stochastic and data-driven cases were addressed.

PhD Summer School organized by IEEE Robotics and Automation Society Jul. 2019

Czech Technical University, Prague, Czech Republic

- **Topics:** multi-robot systems were analyzed from different point of views: from the control perspective to the planning part up to the learning one. Experimental activity on a setup composed of three aerial vehicles has also been carried out.

PhD Summer School organized by the Italian Association of Professors and Researchers in Automation (SIDRA) Jul. 2018

Ce. U. B, Bertinoro (FC), Italy

- **Topics:** two modules were attended, which are "Adaptive Control: analysis and design methods" coordinated by Prof. Andrea Serrani and "Optimization Methods for Decision Making over Networks", coordinated by Prof. Giuseppe Notarstefano and Prof. Maria Prandini. The final test for the certification of credits has been passed

English Course "Trinity GESE" Level 7 (B2) Nov. 2007 - Apr. 2008
Scientific High School "G. Da Procida", Salerno (SA), Italy

TEACHING

Academic tutor for the course "Fundamentals of Automatic Controls" Mar. 2018 - Jun. 2018

University of Salerno, Fisciano (SA), Italy

- **Activity:** didactic support in the field of Automatic Controls to the students enrolled in the second year of Computer Engineering (class of about 100 students); the activity included the preparation of exercises and 1 weekly lesson of 3 hours

Academic tutor for the course "Fundamentals of Programming " Oct. 2016 - Gen. 2017

University of Salerno, Fisciano (SA), Italy

- **Activity:** didactic support in the field of Computer Science to the students enrolled in the first year of Electronic Engineering (class of about 35 students); the activity included the preparation of exercises and 2 weekly lessons of 2 hours each

RESEARCH ACTIVITY

Reseach topics

The research activity mainly concerns the following topics:

- **Control of multi-robot systems.** The objective of this research area is to accomplish cooperative tasks with robot teams. More specifically, particular attention is devoted to decentralized control architectures where the above objective is achieved without a central control unit coordinating the robots, i.e. each robot only relies on information from local sensors and neighboring robots. In this regard, in [1],[6], [9] and [11], a multi-manipulator system has been considered and a two-layer architecture has been adopted for each robot in which, at the top layer, the state of the overall system (comprising the robots with which there is no direct communication) is estimated and, then, it is exploited at the bottom layer to define the local control law. Further actions for managing the human multi-robot interaction have been also addressed as discussed in the following. The devised algorithms [1] have been experimentally validated on the work-cell at the Laboratory of Automation and Robotics at the University of Salerno which is composed of 2 cooperative Comau Smart Six manipulators and a UR10 robot equipped with RGB-D sensor for the monitoring of the cell. In addition, the control of internal stresses that may arise in the case of tight connection between the robots has been investigated [6][11].
  Furthermore, a setup composed of multiple ground and aerial robots for a cooperative transportation task has been analyzed [10]. In particular, the former rigidly grasp the load to transport whereas the latter are attached to it via taut inextensible cables. In this regard, the model of the overall system has been derived considering the respective geometric constraints and an optimal control framework based on the dynamic programming approach has been defined;
  Finally, a distributed fault detection and isolation strategy for multi-manipulator systems has been proposed in [5] and [7] which is based on an observer-controller scheme.
- **Human-robot interaction.** In this context, different types of interaction exist that can be mainly classified in two categories: sharing of the same workspace and physical human-robot collaboration. More specifically, in the case of workspace sharing, the control strategy is supposed to ensure human avoidance at all times in order to prevent unsafe contact. In this regard, a human multi-robot scenario has been considered and a trajectory scaling approach has been proposed [1][8][9] in which the human safety is assessed by a

safety field that takes into account the whole multi-robot system as a source of danger to the human operator and the cooperative task trajectory is then modified so as to ensure a safe interaction while trying to preserve as much as possible the nominal path. In addition, the devised strategy has been implemented in a decentralized fashion and validated on the experimental setup described in the above.
The human multi-robot physical collaboration has also been investigated [6][11] in which multiple manipulators are tightly connected to a common rigid object and the human can physically interact with it. In detail, a two layer solution has been devised in [6][11] where, at the top layer, a virtual dynamic model for the object is defined for a shared control task and an assistance task, respectively, whereas, at the bottom layer, the virtual dynamic model is actually imposed to the object in a decentralized fashion by keeping into account possible internal wrenches that may arise.
Finally, the problem of distinguishing accidental and intentional contacts between humans and robots in a co-existence scenario has been addressed [3]. In particular, a solution based on Recurrent Neural Networks (RNNs) and Gaussian Mixture Models (GMMs) has been proposed to detect and classify the nature of the contact with the human, even in the case the robot is interacting with the environment because of its own task. Then, reaction strategies based on Control Barrier Functions (CBFs) have been devised.

- **Deformable object manipulation.** Deformable objects manipulation is a key component of a variety of both everyday and non-daily applications, ranging from domestic housework to medical scenarios up to industrial setups. However, the large configuration space of deformable objects causes traditional modelling, planning and control approaches to fail when dealing with them. More specifically, unlike in the case of rigid objects, two main challenges arise: i) there is no clear and unified state representation and ii) their dynamics is complex and highly non-linear.
  In order to address them, planning in a low-dimensional latent state space that embeds images has been proposed in [2],[12] in order to define visual and action plans. In particular, a Latent Space Roadmap (LSR) has been devised which is a graph-based structure that globally captures the latent system dynamics. Based on this, two main components are built: a Visual Foresight Module that generates a visual plan as a sequence of images, and an Action Proposal Network that predicts the actions between them. The effectiveness of the method has been shown on a simulated box stacking task as well as a T-shirt folding task performed with a real robot.
  Finally, in order to promote the comparison among different solutions, three benchmarks [4] have been proposed towards three basic tasks in bimanual cloth manipulation: spreading a tablecloth over a table, folding a towel, and dressing. Different complexity levels have been included for each task and baseline solutions for all the tasks have been defined and evaluated according to the proposed metrics.

Experimental activity

The methodological research activity has been supported by the following experimental activity:

- test of algorithms for an assisted dressing task with two Franka Emika Panda [4] robots;
- test of algorithms for T-shirt folding with a dual-arm Baxter robot [2] and use of pytorch for machine learning algorithms;
- test of distributed control algorithms with two Comau Smart Six manipulators [1] equipped with C4G controllers and based on Real-Time Linux/OROCOS programming environment;
- test of distributed control algorithms with multiple mobile MOVO manipulators in Matlab/V-REP programming [7][6] environment as well as on real platform [5]
- test of algorithms for motion planning and human-robot interaction with a UR10 manipulator equipped with RGB-D vision system and based on Linux/ROS programming environment;
- test of algorithms for recognizing and classifying interaction forces with a Kinova Jaco2 robot arm;
- test of variable admittance control algorithms with a Comau Smart Six manipulator

equipped with wrist force sensor and based on Real-Time Linux/OROCOS programming environment.

COMPUTER SKILLS

Experienced in:

- C, C++, Matlab, Python, Java, PHP, HTML, CSS, JavaScript, LaTex languages;
- ROS and OROCOS frameworks;
- V-REP and Gazebo simulation tools;
- MySql and PostgreSQL databases;
- GIT and SVN version control systems;
- Linux-based (even real-time) and Windows operative systems.

PUBLICATIONS

[1] **M. Lippi** and A. Marino, "Human Multi-Robot Safe Interaction: A Trajectory Scaling Approach Based On Safety Assessment," *IEEE Transactions on Control Systems Technology*, pp. 1-16, 2020

[2] **M. Lippi***, P. Poklukar*, M. C. Welle*, A. Varava, H. Yin, A. Marino, and D. Kragic, "Latent Space Roadmap for Visual Action Planning of Deformable and Rigid Object Manipulation," accepted to *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2020

[3] **M. Lippi** and A. Marino, "Enabling Physical Human-Robot Collaboration Through Contact Classification And Reaction," accepted to *IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*, 2020

[4] I. Garcia-Camacho*, **M. Lippi***, M. C. Welle, H. Yin, R. Antonova, A. Varava, J. Borras, C. Torras, A. Marino, G. Alenyà and D. Kragic, "Benchmarking Bimanual Cloth Manipulation", *Robotics and Automation Letters*, 2020

[5] G. Gillini, **M. Lippi**, F. Arrichiello, A. Marino and F. Pierri,"Distributed Fault Detection and Isolation Strategy for a Team of Cooperative Mobile Manipulators", *IET BOOK: Fault Diagnosis and Fault-tolerant Control of Robotic Systems*, Chap. 7, pp. 143-166, 2020

[6] **M. Lippi**, A. Marino and S. Chiaverini, "A Distributed Approach To Human Multi-Robot Physical Interaction," *2019 IEEE International Conference on Systems, Man, and Cybernetics (SMC)*, 2019

[7] G. Gillini, **M. Lippi**, F. Arrichiello, A. Marino and F. Pierri, "Distributed Fault Detection and Isolation for Cooperative Mobile Manipulators," *2019 IEEE International Conference on Systems, Man, and Cybernetics (SMC)*, 2019, **Finalist of the Best Student Paper Award**

[8] **M. Lippi** and A. Marino, "Safety In Human-Multi Robot Collaborative Scenarios: A Trajectory Scaling Approach," *12th IFAC Symposium on Robot Control (SYROCO)*, 2018

[9] **M. Lippi** and A. Marino, "Distributed Kinematic Control and Trajectory Scaling for Multi-Manipulator Systems in Presence of Human Operators," *26th IEEE Mediterranean Conference on Control and Automation (MED)*, 2018

*Contributed equally

[10] **M. Lippi** and A. Marino, "Cooperative Object Transportation by Multiple Ground and Aerial Vehicles: Modeling and Planning," *2018 IEEE International Conference on Robotics and Automation (ICRA)*, 1084-1090, 2018

Under review:

[11] **M. Lippi** and A. Marino, "Human Multi-Robot Physical Interaction: A Distributed Framework," submitted to *Journal of Intelligent and Robotic Systems (second round of review)*

Workshops:

[12] **M. Lippi***, P. Poklukar*, M. C. Welle*, A. Varava, H. Yin, A. Marino, and D. Kragic, "Latent Space Roadmap for Visual Action Planning," *Robotics: Science and Systems (RSS) Workshop on Visual Learning and Reasoning for Robotic Manipulation*, 2020

PARTICIPATION IN CONFERENCES

The following conferences have been attended as speaker:

- *Robotics: Science and Systems (RSS)*, virtually held, on July 2020;
- *IFAC Symposium on Robot Control (SYROCO)*, held in Budapest, Hungary on 27-30 August 2018;
- *IEEE Mediterranean Conference on Control and Automation (MED)*, held in Zara, Croatia on 19-22 June 2018.

MEMBERSHIPS

Member of the National Program Committee for the conference *Workshop on Discrete Event Systems (WODES)*, 2018