Mattia **Pugliatti**

PostDoc. · GNC & Mission design

✉ Mattia.Pugliatti@colorado.edu   ⌂ Italian, 13th of April, 1993, Rho (Milan)   in Mattia Pugliatti

"You never fail until you stop trying"

Research interests

I am a curious, ambitious, and creative researcher. My areas of interest are autonomous optical navigation, artificial intelligence, GNC, and small-bodies exploration. My career goal is to become a specialist in interplanetary missions and autonomous GNC design.

Experience

PostDoctoral fellow
Boulder, Colorado, USA

CU Boulder, *ORCCA laboratory*
Jan. 2024 - Present

- Navigation for deep-space missions
- Artificial intelligence for enhanced optical navigation techniques around small-bodies.

Early Stage Researcher
Milan, Italy

Politecnico di Milano, *DART laboratory*
Nov. 2019 - Nov. 2023

- Artificial intelligence for enhanced optical navigation techniques around small-bodies. Design and validation of autonomous GNC systems for interplanetary CubeSats.
- Marie Skłodowska Curie ESR13 of Stardust-R, the European Training Network on asteroids and space debris.

Visiting researcher
Bremen, Germany

Deutsches Forschungszentrum für Künstliche Intelligenz, *DFKI*
Feb. 2023 - May. 2023

- Visiting researcher at the German center for artificial intelligence under the supervision of Dr. Marko Jankovic and Prof. Frank Kirchner.
- Visual digital twin of an analog crater facility for data-driven applications.
- Dataset generation with a Vicon-drone camera setup. Pose and visual labeling of the images with a digital twin.

Visiting researcher
Tucson, Arizona, USA

University of Arizona, *SSEL*
Sept. 2021 - Jan. 2022

- Visiting researcher at the Space System Engineering Laboratory under the supervision of professor Roberto Furfaro.
- Deep-learning and convolutional extreme learning machine methods for precise optical navigation in the proximity of a small-body.
- Recurrent neural networks and reinforcement learning for autonomous close-proximity operations.

GNC project engineer
Madrid, Spain

GMV, *SPS/GNC division - Interplanetary section*
Sept. 2018 - Sept. 2019

- GNC project engineer of the HERA mission, a technology demonstration mission to visit the Didymos binary system.
- Design and testing of the visual based navigation strategy for the proximity operation phases of the Hera mission for phases A and B1.
- Incremental testing and validation campaign using higher fidelity models: model-in-the-loop (with PANGU), software-in-the-loop and hardware-in-the-loop (responsible for the optical facility testbench and robotic facility simulations).

Visiting researcher
Sagamihara, Japan

JAXA, *Institute of Space and Astronautical Science*
March. 2017 - Nov. 2017

- Visiting researcher under the supervision of professor Yasuhiro Kawakatsu.
- Member of the trajectory design teams of EQUULEUS CubeSat and DESTINY smallsat missions.
- EQUULEUS: 6U CubeSat to be deployed during the maiden flight of the SLS to reach a NRHO about the L2 point of the Earth–Moon system. Team leader of the first-guess trajectory design group. Maintenance and implementation of a toolbox for the generation of large set of first-guess transfer trajectories in full-ephemeris model of the Sun–Earth–Moon system using SPICE and jPRO.
- DESTINY: Technology demonstration mission to investigate Phaethon asteroid. Trajectory design of the multiple lunar flyby phase with the application of a Moon-to-Moon database in the Earth–Moon CR3BP.

Internship

Internship   *Friedrichshafen, Germany*

Airbus Defence and Space, *Future programmes department*   *Jul. 2016 - Dec. 2016*

- Mission and spacecraft design of $NEOT\omega IST$, a low-cost impactor demonstration and characterization mission on Itokawa. Part of the NEOShield-2 project, supported by the European programme H2020.
- Focus on the flyby trajectory and formation flight design, high level assessment of a tracking strategy, and system engineering design of the flyby module.

Education

Politecnico di Milano   *Milan, Italy*

Ph.D. in Aerospace Engineering   *Nov. 2019 - Nov. 2023*

- Artificial intelligence for enhanced optical navigation techniques around small-bodies. Design and validation of autonomous GNC systems for interplanetary CubeSats. Supervisor: Prof. Francesco Topputo.
- Mission analysis, image processing, and GNC design of the Milani mission. Team leader of the GNC group for the Milani mission.
- Thesis on "Data-Driven Image Processing for Enhanced Vision-Based Applications Around Small Bodies with Machine Learning" Polimi repository, cum laude.

Delft University of Technology   *Delft, The Netherlands*

M.Sc. in Spaceflight   *Sep. 2015 - Mar. 2018*

- Specialization in space exploration, transfer orbit profile.
- Key courses: Mission Geometry and Orbit design, Planetary sciences, Astrodynamics I & II, Space Project, Microsatellite engineering.
- Thesis on the Extended Tisserand–Poincaré graph for multi-body trajectory design in the patched CR3BP model: Extension of the current theoretical framework in the CR3BP of the Tisserand parameter about the primary to a modified Tisserand parameter about the secondary, existing on a specific family of Poincaré sections.
- Generic formulation valid for any patched CR3BP model sharing the same body as primary and secondary, with applicability for EQUULEUS and DESTINY in the Sun–Earth–Moon system, and for capture trajectories in the Sun–Jupiter–Europa system.
- Final grade: 9.5/10 Cum Laude. Manuscript available at TU Delft repository.

Politecnico di Milano   *Milan, Italy*

B.Sc. in Aerospace Engineering   *Sep. 2012 - Sep. 2015*

- Key courses: Fundamental of Space Missions, Applied Numerical Analysis, Theoretical Mechanics, Automatic Control.
- Final grade: 106/110.

Publications

2023

J10 **"CORTO: The Celestial Object Rendering TOol at DART Lab"**, **Pugliatti, M.** and Buonagura, C. and Topputo, F. Sensors, 2023, Volume 23, 9595, doi:10.3390/s23239595

J9 **"Characterization of the Ejecta from the NASA/DART Impact on Dimorphos: Observations and Monte Carlo Model"**, Moreno, F. and Bagatin, A. C. and Tancredi, G. and Li, J.Y and Rossi, A. and Ferrari, F. and Hirabayashi, M. and Fahnestock, E. and Maury, A. and Sandness, R. and Rivkin, A. S. and Cheng, A. and Farnham, T. L. and Soldini, S. and Giordano, C. and Merisio, G. and Panicucci, P. and **Pugliatti M.** and Castro-Tirado, A. J. and Fernández-García, E. and Pérez-García, I. and Ivanovski, S. and Penttila, A. and Kolokova, L. and Licandro, J. and Munoz, O. and Gray, Z. and Ortiz,J. L. and Lin, Z.Y. The Planetary Science Journal, 2023, doi:10.3847/PSJ/ace827

J8 **"Onboard State Estimation Around Didymos with Recurrent Neural Networks and Segmentation Maps"**, **M. Pugliatti**, A. Scorsoglio, R. Furfaro, F. Topputo. IEEE Transactions on Aerospace and Electronic Systems, 2023, doi:10.1109/TAES.2023.3288506

J7 **"The vision-based guidance, navigation, and control system of Hera's Milani Cubesat"**, **M. Pugliatti**, F. Piccolo, A. Rizza, V. Franzese, F. Topputo. Acta Astronautica, 2023, Volume 210, Pages 14–28, doi:10.1016/j.actaastro.2023.04.047, preprint

2022

J6 **"Small-Body Segmentation Based on Morphological Features with a U-Shaped Network Architecture"**, **M. Pugliatti**, M. Maestrini. Journal of Spacecraft and Rockets, 2022, Volume 59, Issue 6, Pages 1821–1835, doi: 10.2514/1.A35447, preprint

J5 **"Data-Driven Image Processing for Onboard Optical Navigation Around a Binary Asteroid"**, **M. Pugliatti**, V. Franzese, F. Topputo. Journal of Spacecraft and Rockets, 2022, Volume 59, Issue 3, Pages 943–959, doi: 10.2514/1.A35213, preprint

J4 **"CubeSat landing simulations on small bodies using blender"**, P. Peñarroya, **M. Pugliatti**, F. Ferrari, S. Centuori, F. Topputo, M. Vetrisano, M. Sanjurjo-Rivo. Advances in Space Research, 2022, ISSN 0273-1177, doi:10.1016/j.asr.2022.07.044, preprint

J3 **"Image Processing Robustness Assessment of Small-Body Shapes"**, C. Buonagura, **M. Pugliatti**, F. Topputo. The Journal of the Astronautical Sciences, 2022, Volume 69, Issue 6, Pages 1744–1765, doi:10.1007/s40295-022-00348-6, preprint

2021

J2 **"Preliminary mission profile of Hera's Milani CubeSat"**, F. Ferrari, V. Franzese, **M. Pugliatti**, C. Giordano, F. Topputo. Advances in Space Research, 2021, Volume 67, Issue 6, Pages 2010–2029, doi:10.1016/j.asr.2020.12.034, preprint

J1 **"Trajectory Options for Hera's Milani CubeSat Around (65803) Didymos"**, F. Ferrari, V. Franzese, **M. Pugliatti**, C. Giordano, F. Topputo. The Journal of the Astronautical Sciences, 2021, Volume 68, Issue 4, Pages 973–994, doi:10.1007/s40295-021-00282-z, preprint

Conferences

The contributions marked with * have been personally presented on stage

2024

C27 **"Moon Limb-Based Autonomous Optical Navigation Using Star Trackers"**, C. Balossi, F. Piccolo, P. Panicucci, **M. Pugliatti**, F. Topputo, F. Capolupo, 46th AAS Guidance, Navigation and Control Conference, Breckenridge, Colorado, Feb 2022

C26 **"Resource-Constrained Vision-Based Relative Navigation About Small Bodies"**, F. Piccolo, C. Balossi, P. Panicucci, **M. Pugliatti**, F. Topputo, F. Capolupo, 46th AAS Guidance, Navigation and Control Conference, Breckenridge, Colorado, Feb 2022

2023

C25* **"A multi-scale labeled dataset for boulder segmentation and navigation on small bodies"**, **M. Pugliatti**, M. Maestrini, 74th International Astronautical Congress, Baku, Azerbaijan, October 2023

C24* **"The image processing of Milani: challenges after DART impact"**, **M. Pugliatti**, C. Giordano, F. Topputo, ESA-GNC conference, Sopot, Poland, June 2023

C23 **"The CubeSat Mission FUTURE: a Preliminary Analysis to Validate the On-board Autonomous Orbit Determination"**, C. Buonagura, S. Borgia, **M. Pugliatti**, A. Morselli, F. Topputo, F. Corradino, P. Visconti, L. Deva, A. Fedele, G. Leccese, S. Natalucci, ESA-GNC conference, Sopot, Poland, June 2023

C22 **"The Hera Milani CubeSat mission"**, C. Giordano, F. Ferrari, V. Franzese, **M. Pugliatti**, F. Piccolo, A. Rizza, T. Kohout, F. Dirri, A. Longobardo, C. Gisellu, E. Palomba, M. Cardi, F. Perez-Lissi, P. Martino, I. Carnelli, 5th COSPAR Symposium, 2023, Singapore, Apr 2023

2022

C21* **"The Design Pipeline of the Milani Mission: Overview and Challenges After DART Impact"**, M. Pugliatti, F. Topputo, StardustR Final Conference, Noordwijk, The Netherlands, Nov 2022

C20* **"Enhanced Vision-Based Algorithms about Small Bodies: Lessons learned from the Stardust-R experience"**, M. Pugliatti, F. Topputo, StardustR Final Conference, Noordwijk, The Netherlands, Nov 2022

C19* **"Robust boulder identification under varying illumination conditions"**, M. Pugliatti, F. Topputo, Space Imaging Workshop, Atlanta, Georgia, Oct 2022

C18 **"Hardware-In-the-loop Simulation Framework for CubeSats Proximity Operations: Application to the Milani Mission"**, A. Rizza, F. Piccolo, M. Pugliatti, P. Panicucci, F. Topputo, 73rd International Astronautical Congress, Paris, France, Oct 2022

C17 **"Deep learning for Navigation of Small Satellites about Asteroids: an introduction to the DeepNav Project"**, C. Buonagura, M. Pugliatti, F. Topputo, V. Franzese, F. Topputo, A. Zeqaj, M. Zannoni, M. Varile, I. Bloise, F. Fontana, F. Rossi, L. Feruglio, M. Cardone, AII conference, Reggio Calabria, Italy, Sept 2022

C16* **"Object Recognition Algorithms for the Didymos Binary System"**, M. Pugliatti, F. Piccolo, F. Topputo, AII conference, Reggio Calabria, Italy, Sept 2022

C15 **"Mission analysis and navigation assessment for Hera's Milani CubeSat"**, C. Bottiglieri, F. Piccolo, A. Rizza, M. Pugliatti, V. Franzese, C. Giordano, F. Ferrari, F. Topputo, 4S Symposium, Vilamoura, Portugal, May 2022

C14 **"Procedural minor body generator tool for data-driven optical navigation methods"**, C. Buonagura, M. Pugliatti, F. Topputo, CEAS, Berlin, Germany, May 2022

C13* **"Toward verification and validation of the Milani Image Processing Pipeline in the hardware-in-the-loop testbench TinyV3RSE"**, F. Piccolo, M. Pugliatti, P. Panicucci, F. Topputo, AAS-GNC, Breckenridge, Colorado, Feb 2022

C12* **"Design of the On-Board Image Processing of the Milani Mission"**, M. Pugliatti, F. Piccolo, A. Rizza, V. Franzese, C. Bottiglieri, C. Giordano, F. Ferrari, F. Topputo, AAS-GNC, Breckenridge, Colorado, Feb 2022

C11 **"Improvements and applications of the DART vision-based navigation test-bench TINYV3RSE"**, P. Panicucci, M. Pugliatti, V. Franzese, F. Topputo, AAS-GNC, Breckenridge, Colorado, Feb 2022

C10* **"The Milani mission: overview and architecture of the optical-based GNC system"**, M. Pugliatti, A. Rizza, F. Piccolo, V. Franzese, C. Giordano, C. Bottiglieri, F. Ferrari, F. Topputo, AIAA-SciTech, San Diego, California, Jan 2022

C9* **"TINYV3RSE: The DART Vision-Based Navigation Test-bench"**, M. Pugliatti, P. Panicucci, V. Franzese, F. Topputo, AIAA-SciTech, San Diego, California, Jan 2022

2021

C8 **"Trajectory design and orbit determination of Hera's Milani CubeSat"**, C. Bottiglieri, F. Piccolo, A. Rizza, C. Giordano, M. Pugliatti, V. Franzese, F. Ferrari, F. Topputo, Astrodynamic Specialist Conference, Big Sky [Virtual], California, Aug 2021

C7 **"The Hera Milani CubeSat Mission"**, F. Topputo, F. Ferrari, V. Franzese, M. Pugliatti, C. Giordano, A. Rizza, D. Calvi, G. Ammirante, F. Stesina, A. Esposito, S. Corpino, P. Visconti, R. Diaz de Cerio Goenaga, F. Corradino, A. Santoni, M. Cardi, T. Kohout, F. Perez-Lissi, P. Martino, I. Carnelli, 7th IAA Planetary Defense Conference, Vienna, Austria, Apr 2021

C6 **"Using Blender As Contact Dynamics Engine For Cubesat Landing Simulations Within Impact Crater On Dimorphos"**, P. Peñarroya, **M. Pugliatti**, S. Centuori, F. Topputo, 7th IAA Planetary Defense Conference, Vienna, Austria, Apr 2021

C5* **"Navigation about irregular bodies through segmentation maps"**, **M. Pugliatti**, F. Topputo, 31st Space Flight Mechanics Meeting, Charlotte [Virtual], North Carolina, Feb 2021

C4* **"Onboard Small-Body semantic segmentation based on morphological features with U-Net"**, **M. Pugliatti**, M. Maestrini, P. di Lizia, F. Topputo, 31st Space Flight Mechanics Meeting, Charlotte [Virtual], North Carolina, Feb 2021.

2020

C3* **"Small-Body shape recognition with Convolutional Neural Network and comparison with explicit features based methods"**, **M. Pugliatti**, F. Topputo, Astrodynamic Specialist Conference, Lake Tahoe [Virtual], California, Aug 2020

2017

C2 **"NEOTωIST–Design Study of a Kinetic Impactor Demonstration Mission Featuring NEO Spin Change and Observer Sub-spacecraft"**, K. Engel, **M. Pugliatti**, L. Drube, J.L. Cano, S. Eggl, D, Hestroffer, A. Falke, U. Johann, A. Harris, Planetary Defence Conference 2017, Tokyo, Japan, Aug 2017

2016

C1 **"NEOTωIST-An Asteroid Impactor Mission Featuring Sub-spacecraft for Enhanced Mission Capability"**, K. Engel, **M. Pugliatti**, L. Drube, J.L. Cano, S. Eggl, D, Hestroffer, A. Falke, U. Johann, A. Harris, 67th International Astronautical Congress, Guadalajara, Mexico, Aug 2016

Datasets

D4 **"Datasets of Earth-Venus & Earth-Mars Low-Thrust Interplanetary Transfers"**, (2024), doi: 10.5281/zenodo.10613619. Dataset of fuel-optimal low-thrust transfer trajectories from Earth to Venus and Earth to Mars.

D3 **"A multi-scale labeled dataset for boulder segmentation and navigation around small bodies"**, (2023), doi: 10.5281/zenodo.8231155. A multi-label, multi-scale dataset for segmentation and navigation around small bodies. The dataset characteristics are presented in the work "A multi-scale labeled dataset for boulder segmentation and navigation on small bodies", 74th IAC conference, Baku, Azerbaijan, 2023.

D2 **"The image processing of Milani: challenges after DART impact"**, (2023), doi: 10.5281/zenodo.7962714. A dataset that accompanies the results presented at the ESA-GNC conference in 2023, Sopot, Poland for the work "The Design Pipeline of the Milani Mission: Overview and Challenges After DART Impact". The dataset can be used for phase angle regression from images of the Didymos system

D1 **"DOORS: Dataset fOr bOuldeRs Segmentation"**, (2022), doi: 10.5281/zenodo.7107409. A dataset of segmented boulders seen at various scales and different illumination conditions.

Supervision of M.Sc. thesis

Name	AY	Thesis	Title
Davide Gravina	2022-2023	link	*High-Fidelity Star Simulator for Cameras and Star Trackers*

Fabio Piazza	2022-2023	link	*Mid-range horizon-based optical navigation around the Moon using artificial intelligence*
Marco Galeazzi	2022-2023	link	*Physics-informed neural network for gravity field modeling around Didymos binary system*
Andrea Gallina	2022-2023	link	*Low-thrust station-keeping on libration point orbits leveraging supervised learning*
Giuseppe Addario	2021-2022	link	*Low-thrust spacecraft transfers using physics-informed neural networks*
Leonardo Gubello	2021-2022	link	*Image processing with traditional and artificial intelligence techniques for ship detection*
Lorenzo Beccari	2020-2021	link	*Image processing techniques for vision-based navigation around small bodies*
Francesco Carrasso	2020-2021	link	*A convolutional neural network model as image processing in cislunar environment*
Damien Morin	2020-2021	link	*Optimization of payload operations for a CubeSat in a double asteroid environment*
Marzio Agistri	2020-2021	link	*Star tracker measurement filtering via UF/EKF with recursive prefiltering of IMU reading*
Marco Pavoni	2019-2020	link	*Small bodies centroiding via image processing and convolutional neural network*
Carmine Buonagura	2019-2020	link	*Image processing robustness assessment with procedural generated minor bodies shapes*

Projects contributions

- **COSMICA** (2023): Validation and Verification for optical-based navigation algorithms with Hardware-in-the-loop facilities
- **SPARKS** (2023): Technology demonstration missions for swarms. OSIP-funded.
- **STARNAV** (2022-2023): Vision-based navigation algorithms with Star-trackers.
- **DeepNAV** (2021-2023): Deep-learning methods for feature tracking algorithms around small bodies.
- **FUTURE**(2022-2023): CubeSat autonomous demonstration mission for autonomous optical navigation algorithms.

Space missions contributions

- **MILANI** (2020-2022): Mission analysis and GNC design and analysis, with a particular focus on autonomous OpNav techniques. Team leader of the GNC group. Designer of the image processing software. (2+ years of experience from proposal to phase C)
- **HERA** (2018-2019): Testing of the visual-based navigation strategy. Model-in-the-loop, software-in-the-loop, hardware-in-the-loop with engineering camera model, optical laboratory and robotic facility. (1 year of experience, phases A and B1)
- **EQUULEUS** (2017): Mission analysis and trajectory design in a high-fidelity multi-body system. (9 months of experience, phase A)
- **DESTINY+** (2017): Mission analysis and trajectory design in a patched conics dynamic. (9 months of experience, phase A)
- **NEOTωIST** (2016): Mission and spacecraft design, flyby trajectory and formation flight design, high-level assessment of a tracking strategy, and system engineering of the flyby module. (5 months of experience, phase 0)

Honors & Awards

Rocca fellowship
Boston-Milan

MIT-Politecnico di Milano
May 2022

- Scholarship provided to fund 6-12 months of research stays at the Massachusetts Institute of Technology for 5 Politecnico di Milano Ph.D. students every year. Progetto Roberto Rocca.
- A grant provided with the aim to increase the exchange of ideas between the two institutions and establish relationship between research labs.

Scholarship for 74th IAC and 21st SGC
Rome

ASI (Italian Space Agency)
June 2023

- Scholarship provided to Italian researchers to participate to the 74th IAC and 21st SGC in Baku, Azerbaijan. ASI scholarship.
- 5 Scholarships awarded in Italy in 2023.

Aerospace 2023 Travel Award
Basel

MPDI
May 2023

- Monetary award of CHF 500 to take part in international conferences in the aerospace community.
- 3 researchers awarded in 2023 MDPI award.

Technical skills

- Programming languages and software: Python, Matlab, Simulink, STK, jPRO, C++, LaTeX.
- Operative systems: Linux, Microsoft, MacOS.
- Others: Blender, PANGU, Git, SPENVIS, Excel, Word, Powerpoint.
- Teamwork: Problem-solving, extensive experience in international teams (7+ years), fit for leadership positions, at ease with pressure.

Languages and personal interests

- Italian (Mother tongue), English (Advanced, TOEFL: 114/120 Nov 2017), Spanish & German (basic).
- I love backpacking, traveling around the world, exploring disparate cultures, and tasting the most extravagant foods.