

*Last updated on December 17, 2023*

## Activities

[2022- ] **Principal Research Scientist**, at MERL Mitsubishi Electric Research Labs, Cambridge;

[2019-2022] **Assistant Research Professor** (*Inv. Aux.*), at “Instituto Superior Técnico, Lisboa”;

[2018-2019] **Post-Doctoral Associate**, at KTH Royal Institute of Technology, Stockholm;

[2014-2018] **Post-Doctoral Researcher**, at “Instituto Superior Técnico, Lisboa”;

## Education

[2009-2013] **PhD degree** at the University of Coimbra (ECE);

[2007-2008] **MSc degree** at the University of Coimbra (ECE);

[2003-2007] **BSc degree** at the University of Coimbra (ECE);

## Awards

[2023] **ATC-M**, Development of location-based system technologies for ADAS/Autonomous;

[2018] **Outstanding Reviewer Award**, Computer Vision and Image Understanding (CVIU);

[2003-2008] **Academic merit** (four times – years **2004/2005, 2005/2006, 2006/2007, and 2007/2008**), Name of the award: “Prémio 3% dos Melhores Estudantes” (best 3% student award).;

## Research Grants

[2016-2022] **Individual Post-Doctoral grant**: Awarded by the Portuguese Foundation for Science and Technology (FCT), Reference: SFRH/BPD/111495/2015;

[2009-2013] **PhD grant**: Awarded by the Portuguese Foundation for Science and Technology (FCT), Reference: SFRH/BD/49054/2008;

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## Research

### Publications

#### CVPR, ECCV, ICCV, ICRA, IROS, and Journal papers

[J39] Arihant Gaur, G. Dias Pais, **Pedro Miraldo**, **Valter Piedade**, and Pedro Miraldo. “Oriented-grid Encoder for 3D Implicit Representations”. In: *Int’l Conf. 3D Vision (3DV)*. [doi]. 2023.

[J38] Valter Piedade and **Pedro Miraldo**. “BANSAC: A dynamic BAYesian Network for adaptative SAmple Consensus”. In: *IEEE/CVF Int’l Conf. Computer Vision (ICCV)*. [[arXiv:2309.08690](https://arxiv.org/abs/2309.08690),doi]. 2023.

- [J37] Fabien Delattre, Dave Dirnfeld, Phat Nguyen, Stephen Scarano, **Mike Jones**, Pedro Miraldo, and Erik Learned-Miller. “Robust Frame-to-Frame Camera Rotation Estimation in Crowded Scenes”. In: *IEEE/CVF Int’l Conf. Computer Vision (ICCV)*. [[arXiv:2309.08588](#),doi]. 2023.
- [J36] Andre Mateus, Siddhant Ranade, Srikumar Ramalingam, and **Pedro Miraldo**. “Fast and Accurate 3D Registration from Line Intersections Constraints”. In: *Int’l J. Computer Vision (IJCV)* 131 (2023). [[doi](#)], pp. 2044–2069.
- [J35] **Pedro Miraldo** and José Iglesias. “A Unified Model for Line Projections in Catadioptric Cameras with Rotationally Symmetric Mirrors”. In: *IEEE/CVF Conf. Computer Vision and Pattern Recognition (CVPR)*. [[doi](#)]. 2022, pp. 15776–15785.
- [J34] André Mateus, Pedro U. Lima, and **Pedro Miraldo**. “An observer cascade for velocity and multiple line estimation”. In: *IEEE Int’l Conf. Robotics and Automation (ICRA)*. [[arXiv:2203.01879](#),doi]. 2022, pp. 9418–9424.
- [J33] João R. Cardoso and **Pedro Miraldo**. “Solving the discrete Euler–Arnold equations for the generalized rigid body motion”. In: *Journal of Computational and Applied Mathematics (CAM)* 402 (2022). [[arXiv:2109.00505](#), doi], p. 113814.
- [J32] André Mateus, Omar Tahri, A. Pedro Aguiar, Pedro U. Lima, and **Pedro Miraldo**. “On Incremental Structure-from-Motion using Lines”. In: *IEEE Trans. Robotics (T-RO)* 38.1 (2022). [[arXiv:2105.11196](#), doi], pp. 391–406.
- [J31] Siddhant Ranade, Yu Xin, Shantnu Kakkar, **Pedro Miraldo**, and Srikumar Ramalingam. “Mapping of Sparse 3D Data using Alternating Projection”. In: *Asian Conf. Computer Vision (ACCV)*. [[arXiv:2010.02516](#),doi] – **Oral presentation**. 2020, pp. 295–313.
- [J30] Pedro Roque, Elisa Bin, **Pedro Miraldo**, and Dimos V. Dimarogonas. “Fast Model Predictive Image-Based Visual Servoing for Quadrotors”. In: *IEEE/RSJ Int’l Conf. Intelligent Robots and Systems (IROS)*. [[doi](#)]. 2020, pp. 7566–7572.
- [J29] **Pedro Miraldo** and João R. Cardoso. “On the Generalized Essential Matrix Correction: An efficient solution to the problem and its applications”. In: *Journal of Mathematical Imaging and Vision (JMIV)* 62 (2020). [[arXiv:1709.06328](#), doi], pp. 1107–1120.
- [J28] André Mateus, Srikumar Ramalingam, and **Pedro Miraldo**. “Minimal Solvers for 3D Scan Alignment with Pairs of Intersecting Lines”. In: *IEEE/CVF Conf. Computer Vision and Pattern Recognition (CVPR)*. [[doi](#)]. 2020, pp. 7232–7242.
- [J27] G. Dias Pais, Srikumar Ramalingam, Venu Madhav Govindu, Jacinto C. Nascimento, Rama Chellappa, and **Pedro Miraldo**. “3DRegNet: A Deep Neural Network for 3D Point Registration”. In: *IEEE/CVF Conf. Computer Vision and Pattern Recognition (CVPR)*. [[arXiv:1904.01701](#),doi]. 2020, pp. 7191–7201.
- [J26] R. T. Rodrigues, **P. Miraldo**, D. V. Dimarogonas, and A. P. Aguiar. “Active Depth Estimation: Stability Analysis and its Applications”. In: *IEEE Int’l Conf. Robotics and Automation (ICRA)*. [[arXiv:2003.07137](#),doi]. 2020, pp. 2002–2008.
- [J25] P. U. Lima et al. “SocRob@Home Integrating AI Components in a Domestic Robot System”. In: *Künstliche Intelligenz (KI)* 33.4 (2019). [[doi](#)], pp. 343–356.
- [J24] R. Rodrigues, **P. Miraldo**, D. V. Dimarogonas, and A. P. Aguiar. “A Framework for Depth Estimation and Relative Localization of Ground Robots using Computer Vision”. In: *IEEE/RSJ Int’l Conf. Intelligent Robots and Systems (IROS)*. [[arXiv:1908.00309](#), doi]. 2019, pp. 3719–3724.

- [J23] **P. Miraldo**, S. Saha, and S. Ramalingam. “Minimal Solvers for Mini-Loop Closures in 3D Multi-Scan Alignment”. In: *IEEE/CVF Conf. Computer Vision and Pattern Recognition (CVPR)*. [[arXiv:1904.03941](#), [doi](#)]. 2019, pp. 9691–9700.
- [J22] G. Pais, J. C. Nascimento, and **P. Miraldo**. “OmniDRL: Robust Pedestrian Detection using Deep Reinforcement Learning on Omnidirectional Cameras”. In: *IEEE Int’l Conf. Robotics and Automation (ICRA)*. [[arXiv:1903.00676](#), [doi](#)]. 2019, pp. 4782–4789.
- [J21] J. Campos, J. R. Rodrigues, and **P. Miraldo**. “POSEAMM: A Unified Framework for Solving Pose Problems using an Alternating Minimization Method”. In: *IEEE Int’l Conf. Robotics and Automation (ICRA)*. [[arXiv:1904.04858](#), [doi](#)]. 2019, pp. 3493–3499.
- [J20] A. Mateus, D. Ribeiro, **P. Miraldo**, and J. C. Nascimento. “Efficient and Robust Pedestrian Detection using Deep Learning for Human-Aware Navigation”. In: *Robotics and Autonomous Systems (RAS)* 113 (2018). [[arXiv:1607.04441](#), [doi](#)], pp. 23–37.
- [J19] **P. Miraldo**, T. Dias, and S. Ramalingam. “A Minimal Closed-Form Solution for Multi-Perspective Pose Estimation using Points and Lines”. In: *European Conf. Computer Vision (ECCV)*. [[arXiv:1807.09970](#), [doi](#)]. 2018, pp. 490–507.
- [J18] A. Mateus, O. Tahri, and **P. Miraldo**. “Active Structure-from-Motion for 3D Straight Lines”. In: *IEEE/RSJ Int’l Conf. Intelligent Robots and Systems (IROS)*. [[arXiv:1807.00753](#), [doi](#)]. 2018, pp. 5819–5825.
- [J17] **P. Miraldo**, F. Eiras, and S. Ramalingam. “Analytical Modeling of Vanishing Points and Curves in Catadioptric Cameras”. In: *IEEE/CVF Conf. Computer Vision and Pattern Recognition (CVPR)*. [[arXiv:1804.09460](#), [doi](#)]. 2018, pp. 2012–2021.
- [J16] R. Rodrigues, M. Basiri, A. P. Aguiar, and **P. Miraldo**. “Low-level Active Visual Navigation: Increasing robustness of vision-based localization using potential fields”. In: *IEEE Robotics and Automation Letters (RA-L) and IEEE Int’l Conf. Robotics and Automation (ICRA)* 3.3 (2018). [[arXiv:1801.07249](#), [doi](#)], pp. 2079–2086.
- [J15] X. Liu, Z. Li, K. Zhong, Y. Chao, **P. Miraldo**, and Y. Shi. “Generic distortion model for metrology under optical microscopes”. In: *Optics and Lasers in Engineering (OLEN)* 103 (2018). [[doi](#)], pp. 119–126.
- [J14] J. Iglésias, **P. Miraldo**, and R. Ventura. “Towards an Omnidirectional Catadioptric RGB-D Camera”. In: *IEEE/RSJ Int’l Conf. Intelligent Robots and Systems (IROS)*. [[doi](#)]. 2016, pp. 2506–2513.
- [J13] T. Veiga, **P. Miraldo**, R. Ventura, and P. Lima. “Efficient Object Search for Mobile Robots in Dynamic Environments: Semantic Map as an Input for the Decision Maker”. In: *IEEE/RSJ Int’l Conf. Intelligent Robots and Systems (IROS)*. [[doi](#)]. 2016, pp. 2745–2750.
- [J12] X. Liu, Z. Li, **P. Miraldo**, K. Zhong, and Y. Shi. “A framework to calibrate the scanning electron microscope under any magnifications”. In: *IEEE Photonics Technology Letters (PT-L)* 28.16 (2016). [[doi](#)], pp. 1715–1718.
- [J11] T. Dias, **P. Miraldo**, and N. Gonçalves. “A Framework for Augmented Reality using Non-Central Catadioptric Cameras”. In: *Springer J. Intelligent & Robotic Systems (JINT)* 83.3 (2016). [[doi](#)], pp. 359–373.
- [J10] F. Amigoni et al. “Competitions for Benchmarking: Task and Functionality Scoring Complete Performance Assessment”. In: *IEEE Robotics Automation Magazine (RA-M)* 22.3 (2015). [[doi](#)], pp. 53–61.
- [J9] T. Dias, **P. Miraldo**, N. Gonçalves, and P. Lima. “Augmented Reality on Robot Navigation using Non-Central Catadioptric Cameras”. In: *IEEE/RSJ Int’l Conf. Intelligent Robots and Systems (IROS)*. [[doi](#)]. 2015, pp. 4999–5004.

- [J8] **P. Miraldo** and H. Araujo. “Pose Estimation for Non-Central Cameras Using Planes”. In: *Springer J. Intelligent & Robotic Systems (JINT)* 80.3 (2015). [doi], pp. 595–608.
- [J7] **P. Miraldo** and H. Araujo. “Generalized Essential Matrix: Properties of the Singular Value Decomposition”. In: *Image and Vision Computing (IVC)* 34 (2015). [doi], pp. 45–50.
- [J6] **P. Miraldo**, H. Araujo, and N. Gonçalves. “Pose Estimation for General Cameras Using Lines”. In: *IEEE Trans. Cybernetics (T-CYB)* 45.10 (2015). [doi], pp. 2156–2164.
- [J5] **P. Miraldo** and H. Araujo. “Direct Solution to the Minimal Generalized Pose”. In: *IEEE Trans. Cybernetics (T-CYB)* 45.3 (2015). [doi], pp. 404–415.
- [J4] **P. Miraldo** and H. Araujo. “Planar Pose Estimation for General Cameras using Known 3D Lines”. In: *IEEE/RSJ Int’l Conf. Intelligent Robots and Systems (IROS)*. [doi]. 2014, pp. 4234–4240.
- [J3] **P. Miraldo** and H. Araujo. “A Simple and Robust Solution to the Minimal General Pose Estimation”. In: *IEEE Int’l Conf. Robotics and Automation (ICRA)*. [doi]. 2014, pp. 2119–2125.
- [J2] **P. Miraldo** and H. Araujo. “Calibration of Smooth Camera Models”. In: *IEEE Trans. Pattern Analysis and Machine Intelligence (T-PAMI)* 35.9 (2013). [doi], pp. 2091–2103.
- [J1] **P. Miraldo**, H. Araujo, and J. Queiró. “Point-based Calibration Using a Parametric Representation of General Imaging Models”. In: *IEEE/CVF Int’l Conf. Computer Vision (ICCV)*. [doi]. 2011, pp. 2304–2311.

## Book Chapters

- [B2] Helder Jesus Araujo, **Pedro Miraldo**, and Nathan Crombez. “Omnidirectional Vision”. In: doi. ISTE, 2023. Chap. Localization and Navigation with Omnidirectional Images, pp. —.
- [B1] L. Iocchi, G. Kraetzschmar, D. Nardi, P. U. Lima, **P. Miraldo**, and E. Bastianelli. “Joint vehicle positioning and road-map estimation”. In: Application Filed. InTechOnline, 2017, pp. 25–46.

## Other Conferences

- [C13] Yuri Shimane, **Pedro Miraldo**, Karl Berntorp, Marcus Greiff, and Avishai Weiss. “High-Fidelity Simulation of Horizon-Based Optical Navigation with Open-Source Software”. In: *International Astronautical Congress (IAC)*. [merl-tr]. 2023.
- [C12] Karl Berntorp, Marcus Greiff, Stefano Di Cairano, and **Pedro Miraldo**. “Bayesian Sensor Fusion for Joint Vehicle Localization and Road Mapping Using Onboard Sensors”. In: *Int’l Conf. on Information Fusion (FUSION)*. [doi]. 2023, pp. 1–8.
- [C11] A. Mateus, O. Tahri, and **P. Miraldo**. “Active Estimation of 3D Lines in Spherical Coordinates”. In: *American Control Conf. (ACC)*. [arXiv:1902.00473, doi]. 2019, pp. 3950–3955.
- [C10] R. Rodrigues, M. Basiri, A. P. Aguiar, and **P. Miraldo**. “Feature Based Potential Field for Low-level Active Visual Navigation”. In: *Iberian Robotics Conf. (ROBOT)*. [arXiv:1709.04687, doi]. 2017, pp. 791–800.
- [C9] D. Ribeiro, A. Mateus, **P. Miraldo**, and J. C. Nascimento. “A Real-Time Deep Learning Pedestrian Detector for Robot Navigation”. In: *IEEE Int’l Conf. on Autonomous Robot Systems and Competitions (ICARSC)*. [arXiv:1607.04436, doi]. 2017, pp. 165–171.
- [C8] T. Dias, H. Araujo, and **P. Miraldo**. “3D Reconstruction with Low-Resolution, High Radial Distortion Stereo Images”. In: *ACM Int’l Conf. on Distributed Smart Cameras (ICDSC)*. [arXiv:1709.06451, doi]. 2016, pp. 98–103.

- [C7] J. Cardoso, **P. Miraldo**, and H. Araujo. “Plicker correction problem: Analysis and improvements in efficiency”. In: *IEEE Int’l Conf. Pattern Recognition (ICPR)*. [[arXiv:1602.05990](#),[doi](#)]. 2016, pp. 2796–2801.
- [C6] R. Ventura, M. Basiri, A. Mateus, J. Garcia, **P. Miraldo**, P. Santos, and P. U. Lima. “A Domestic Assistive Robot Developed Through Robotic Competitions”. In: *WS Autonomous Mobile Service Robots, joint with Int’l Joint Conference on Artificial (IJCAI)*. 2016.
- [C5] A. Mateus, **P. Miraldo**, P. Lima, and J. Sequeira. “Human-Aware Navigation using External Omnidirectional Cameras”. In: *Iberian Robotics Conf. (ROBOT)*. [[doi](#)]. 2015, pp. 283–295.
- [C4] Tiago Dias, **Pedro Miraldo**, and Nuno Goncalves. “A Framework for Augmented Reality using Non-Central Catadioptric Cameras”. In: *IEEE Int’l Conf. on Autonomous Robot Systems and Competitions (ICARSC)*. [[doi](#)]. 2015, pp. 213–220.
- [C3] **Pedro Miraldo** and Helder Araujo. “Pose Estimation for Non-Central Cameras Using Planes”. In: *IEEE Int’l Conf. on Autonomous Robot Systems and Competitions (ICARSC)*. [[doi](#)]. 2014, pp. 104–109.
- [C2] **Pedro Miraldo** and Helder Araujo. “Improving the Resolution of the Generic Camera Model by Means of a Parametric Representation”. In: *Portuguese Conf. Automatic Control (CONTROLO)*. 2010.
- [C1] **Pedro Miraldo** and Helder Araujo. “Gestures Interpretation Using Computer Vision for Human-Machine Interaction”. In: *Portuguese Conf. Pattern Recognition (RECPAD)*. 2008.

## Research Impact

### Invited Talks

- [04/2021]: Mitsubishi Electric Research Laboratories (MERL), Cambridge, MA;  
Title: **Localization and Mapping: 3D Registration, Omnidirectional cameras, and Active SfM**;
- [06/2019]: Microsoft Research, HoloLens team, Zurich;  
Title: **Robust Pose Estimation: Multi-perspective absolute pose and 3D Scan Alignment**;
- [01/2019]: Ericsson Research, Kista, Stockholm;  
Title: **Non-Conventional Imaging Devices and their Applications in Robotics**;
- [03/2018]: KTH Royal Institute of Technology, Stockholm, Department of Automatic Control;  
Title: **Non-Conventional Imaging Devices and their Applications in Robotics**;

## Principal Investigator (PI) in Research Projects

- [2020-2023] **STORESLAM**: Accurate Agent Localization and Mapping Methods for Structured Indoor Retail Store Environments [[link](#)];

## Participation in Research Projects

- [2016-2018] **RockEU2**: Robotics coordination action for Europe two [[link](#)];
- [2014-2015] **RoCKIn**: Robot competitions kick innovation in cognitive systems and robotics [[link](#)];
- [2018-2019] **COIN**: Co-adaptive human-robot interactive systems [[link](#)];
- [2016-2019] **HaRoDE**: Human-aware service robots for domestic environments [[link](#)];
- [2014-2016] **SocRob**: Soccer Robots and Society of Robots [[link](#)];



[2013-2014] “Novas Tecnologias para apoio à Saúde e Qualidade de Vida:

Projecto A-Cirurgia e Diagnóstico Assistido por Computador Usando Imagem”;

[2012-2015] Calibration and 3D Reconstruction in Omnidirectional Catadioptric Systems [[link](#)];

[2011-2012] Automatic heart scan with ultrasound using visual servoing techniques;

[2010-2013] **UniProjection**: Unified Projection Model of Non SVP Systems – Application to Endoscopy and Graphics [[link](#)];

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# Teaching and Supervision

## Teaching and Supervision

[2021-2022] **Artificial Intelligence and Decision Systems** (ECE,DCE,AerE);

[2020-2021] **Artificial Intelligence and Decision Systems** (ECE,DCE,AerE);

[2017-2018] **Computer Graphics** (CS&E);

[2016-2017] **Algorithms & Data Structures** (ECE);

[2015-2016] **Automatic Control** (ECE);

[2014] **Computer Vision; and Mobile Robotics** (ECE);

## Students

### Completed PhD

**#1: André Mateus** (2017-2021): *On the Exploitation of 3D Straight Lines for Active Mapping and Camera Localization*. Distinction and Honour by unanimity (the highest grade)

### Ongoing PhD

**#2: G. Dias Pais** (2020-): *All SLAM leads to Rome: Localize and Map Dynamic Environments with 3D Sensors and Semantic Information*.

**#3: Valter Piedade** (2022-): *Real-time SLAM in Indoor Environments*.

**#4: Andre Nogueira** (2023-): *Online Visual-Inertial Framework for Navigation*.

### Interns

**#1: Fabien Delattre** (2023);

**#2: Jiachen Liu** (2023);

**#3: G. Dias Pais** (2022);

**#4: Arihant Gaur** (2022);

**#5: Arihant Gaur** (2021-2022);

## **Other Research Grants (Graduate and Undergraduate)**

**#6: Luis Lopes** (2020-2021);

**#7: Valter Piedade** (2020-2021);

**#8: G. Dias Pais** (2018-2019);

**#9: João Campos** (2017-2018);

**#10: Tiago Dias** (2015-2019);

**#11: Francisco Eiras** (2017-2018);

**#12: Rômulo Rodrigues** (2016-2017);

**#13: José Iglesias** (2015-2017);