BRUNO LACERDA

Senior Researcher in Robotics
https://ori.ox.ac.uk/~bruno
bruno@robots.ox.ac.uk

ABOUT ME

I am currently a Senior Researcher in Robotics at the Goal-Oriented Long-Lived Systems (GOALS) Lab, Oxford Robotics Institute, University of Oxford. My research focuses on the intersection of decision making under uncertainty, formal methods and mobile robotics. In particular, I am interested on the use of a combination of techniques from learning, planning and model checking to synthesise intelligent, robust and verifiable behaviour, both for single and for multi-robot systems.

Research Interests

- Sequential Decision Making under Uncertainty
- Probabilistic Model Checking
- Planning for Robotics
- Multi-Robot Coordination
- Service Robotics
- Discrete Event Systems

EDUCATION

Instituto Superior Técnico, Lisbon, Portugal

- **PhD in Electrical and Computer Engineering** 2009–2013
  Thesis: Supervision of Discrete Event Systems Based on Temporal Logic Specifications
  Advisor: Pedro U. Lima
- **MSc in Mathematics and Applications** 2002–2007
  Thesis: Linear-Time Temporal Logic Control of Discrete Event Systems
  Advisors: Pedro U. Lima, Francisco M. Dionísio
- **BSc in Applied Mathematics and Computation** 2002–2007

RESEARCH POSITIONS

Oxford Robotics Institute, University of Oxford, Oxford, UK

- Senior Researcher in Robotics September 2018 – Present
- Postdoctoral Research Assistant in Robotics September 2017 – September 2018

University of Birmingham, Birmingham, UK April 2013 – September 2017

- Postdoctoral Research Fellow in Intelligent Robotics

Örebro University, Örebro, Sweden September 2008 – December 2008

- Research Intern

Instituto Superior Técnico, Lisbon, Portugal March 2008 – August 2008

- Research Intern

CONTRIBUTION TO PROJECTS

University of Oxford

- Offshore Robotics for Certification of Assets (ORCA). UK Research and Innovation
- Robotics and Artificial Intelligence for Nuclear (RAIN). UK Research and Innovation

University of Birmingham

- Spatio-Temporal Representations and Activities for Cognitive Control in Long-Term Scenarios (STRANDS). EU-FP7
- Novel Dynamic Vehicle Scheduling and Path Planning Algorithms for Mobile Robotic and AGV Warehouse Order Picking. TSB Smart Award
- Learning the Structure and Dynamics of Human Environments to Support Intelligent Mobile Robot Behaviour. EPSRC First Grant

TEACHING

University of Oxford

- Lecturer: Probabilistic Model Checking — Michaelmas Term 2018
  Shared lecturing duties with Marta Kwiatkowska

University of Birmingham

- Invited Lectures: Robot Programming — Semester 2 2015/2016, 2016/2017
  Delivered two lectures each year on multi-robot coordination
- Lecturer: Intelligent Robotics — Semester 1 2014/2015
  Shared lecturing duties with Chris Burbridge and Lars Kunze
- Invited Research Lecture: Intelligent Robotics — Semester 1 2013/2014
- Demonstrator: Foundations of Computer Science — Semester 1 2013/2014

STUDENT SUPERVISION

University of Oxford

- PhD Co-Supervisor (w/ Nick Hawes): Charlie Street — September 2018 – Present
  Topic: AI for Multi-Robot Systems
- PhD Co-Supervisor (w/ Nick Hawes): Marc Rigter — September 2018 – Present
  Topic: Shared Autonomy with Formal Guarantees
- PhD Co-Supervisor (w/ Nick Hawes): Michael Painter — September 2018 – Present
  Topic: Multi-Objective Mission Planning
- 4th Year Project Supervisor: Han Zhou — October 2018 – Present
  Topic: Auctioning for Multi-Robot Coordination

University of Birmingham

- PhD Co-Supervisor (w/ David Parker and Nick Hawes): Fatma Faruq — February 2017 – Present
  Topic: Simultaneous Task Allocation and Planning under Uncertainty
- PhD Co-Supervisor (w/ Nick Hawes): Lenka Mudrova — June 2014 – September 2017
  Topic: Task Scheduling and Merging in Space and Time
- MSc Summer Project (w/ Jeremy Wyatt): Milan Tomy — June 2017 – September 2017
  Topic: Battery Scheduling in Autonomous Mobile Robots
- BSc Final Year Project (w/ Nick Hawes): Joseph Shaw — October 2016 – April 2017
  Topic: Auctioning for Multi-Robot Coordination
- MSc Summer Project (w/ Nick Hawes): Pedro Elias — June 2015 – September 2015
  Topic: Multi-agent Path Finding
- MSc Summer Project (w/ Nick Hawes): Eliot Dixon — June 2014 – September 2014
  Topic: MDP Models for Mobile Service Robots
- MSc Summer Project (w/ Nick Hawes): Ken Poyner — June 2013 – September 2013
  Topic: Autonomous Navigation Cost Estimation In Mobile Robots

RESEARCH VISITS

Delft University of Technology, Delft, The Netherlands May 2016 – July 2016

· Host: Matthijs Spaan

University of California, Los Angeles, CA, USA September 2011 – December 2011

· Host: Paulo Tabuada

University Carlos III de Madrid, Madrid, Spain March 2010 – June 2010

· Host: Miguel A. Salichs

AWARDED FUNDING

LEaDing Fellows, a Marie Curie COFUND Programme July 2018
2 Year Fellowship, hosted at TU Delft

· Research Proposal: "Cooperative Multi-Robot Transportation Systems with Guaranteed Quality of Service"

· Declined opportunity and stayed at University of Oxford

LES & EPS PERCAT Career Development Competition, University of Birmingham March 2016

· Travel support for research visit to TU Delft

Ramsay Research Travel Fund, School of Computer Science, University of Birmingham March 2016

· Subsistence support for research visit to TU Delft

Fundação para a Ciência e Tecnologia, Portugal

· Funding for PhD student research visit to UCLA April 2011

· Funding for PhD student research visit to UC3M November 2009

· Individual PhD studentship January 2009 – December 2012

INVITED TALKS

· Workshop on Formal Methods in AI, University of Naples Federico II, Naples, Italy February 2017
· Computer Science Department Seminar Series, University of Liverpool, UK March 2017
· Robolog Workshop, IRISA, Rennes, France June 2017
· Full-day Tutorial at 4th Lucia PhD School on AI and Robotics, Lisbon, Portugal September 2017

SERVICE

University of Oxford

· Lead robot demo at Pembroke College Open Day June 2019
· Lead robot demo at Blenheim Palace, Woodstock, Oxfordshire January 2019
· Participated in robot demo at Pembroke College Open Day June 2018
· Engineering Research Associate at Pembroke College August 2018 – Present
· Organiser of the Oxford Robotics Research Group Seminars (w/ Siddharth Narayanaswamy) May 2018 – Present

University of Birmingham

· Participated in several robot demos at various locations, e.g., London's Museum of Natural History, Birmingham's Think Tank, School of Computer Science and University of Birmingham's Open Days 2014 – 2018

Reviewing

· Artificial Intelligence (AIJ)
· IEEE Transactions on Automatic Control (TACON)
· IEEE Robotics & Automation Magazine (RAM)
· Discrete Event Dynamic Systems (DEDS)
· IEEE Transactions on Automation Science and Engineering (T-ASE)
· IEEE Control Systems Letters (L-CSS)
· IEEE Transactions on Systems, Man, and Cybernetics (SMC)
· IEEE Transactions on Intelligent Systems (IS)
· ACM Transactions on Autonomous and Adaptive Systems (TAAS)
· Formal Aspects of Computing (FAOC)
· International Joint Conference on Artificial Intelligence (IJCAI) - 2017 – 2019
· AAAI Conference on Artificial Intelligence (AAAI) - 2018, 2019
· International Conference on Autonomous Agents and Multiagent Systems (AAMAS) - 2014, 2016 – 2019
· International Conference on Automated Planning and Scheduling (ICAPS) - 2016 – 2019
· European Conference of Artificial Intelligence (ECAI) - 2016, 2018
· International Conference on Tools and Algorithms for the Construction and Analysis of Systems (TACAS) - 2017
· International Symposium on Distributed Autonomous Robotic Systems (DARS) - 2014
· IEEE International Conference on Robotics and Automation (ICRA) - 2015, 2018
· IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) - 2015 – 2019
· IEEE Conference on Decision and Control (CDC) - 2018, 2019
· American Control Conference (ACC) - 2016, 2018
· IEEE International Conference on Automation Science and Engineering (CASE) - 2015, 2016
· Formal Methods for Autonomous Systems Workshop @ FM - 2019
· AAAI Spring Symposium on Integrating Representation, Reasoning, Learning, and Execution for Goal Directed Autonomy - 2018
· Introspective Methods for Reliable Autonomy Workshop @ IROS - 2017 Workshop on Autonomous Mobile Service Robots @ IJCAI - 2016
· AI for Long-term Autonomy Workshop @ ICRA - 2016
· Workshop on Autonomous Robots and Multirobot Systems @ AAMAS - 2016 Workshop on Artificial Intelligence and Robotics @ AAAI - 2014, 2016
· AAAI Robotics Fellowships - 2015, 2016

INDUSTRY POSITIONS

Everis, Consulting, IT, Outsourcing & Professional Services, Lisbon, Portugal September 2007 - February 2008

· Junior Consultant

Mercer Human Resource Consulting, Lisbon, Portugal April 2006 – September 2006

· Part-time Collaborator

PUBLICATIONS

[1] Bruno Lacerda, Fatma Faruq, David Parker, and Nick Hawes. "Probabilistic Planning with Formal Performance Guarantees for Mobile Service Robots". In: *International Journal of Robotics Research (IJRR)* (2019).

[2] Milan Tomy, Bruno Lacerda, Nick Hawes, and Jeremy Wyatt. "Battery Charge Scheduling in Long-Life Autonomous Mobile Robots". In: *Proc. of the 2019 European Conf. on Mobile Robots (ECMR)*. Prague, Czech Republic, 2019.

[3] Masoumeh Mansouri, Bruno Lacerda, Nick Hawes, and Federico Pecora. "Multi-Robot Planning Under Uncertain Travel Times and Safety Constraints". In: *Proc. of the 28th Int. Joint Conf. on Artificial Intelligence (IJCAI)*. Macau, China, 2019.

[4] Masoumeh Mansouri, Bruno Lacerda, Nick Hawes, and Federico Pecora. "Multi-Robot Planning Under Uncertain Travel Times and Safety Constraints". In: *ICRA 2019 Workshop on Resilient Robot Teams: Composing, Acting, and Learning*. Montreal, Canada, 2019.

[5] Bruno Lacerda, David Parker, and Nick Hawes. "Policy Generation with Probabilistic Guarantees for Long-term Autonomy of a Mobile Robot". In: *FLoC 2018 Workshop on the Verification and Validation of Autonomous Systems (VaVAS)*. Oxford, United Kingdom, 2018.

[6] Fatma Faruq, Bruno Lacerda, Nick Hawes, and David Parker. "Simultaneous Task Allocation and Planning Under Uncertainty". In: *Proc. of the 2018 IEEE/RSJ Int. Conf. on Intelligent Robots and Systems (IROS)*. Madrid, Spain, 2018.

[7] Bruno Lacerda, David Parker, and Nick Hawes. "Multi-Objective Policy Generation for Mobile Robots Under Probabilistic Time-Bounded Guarantees". In: *Proc. of the 27th Int. Conf on Automated Planning and Scheduling (ICAPS)*. Pittsburgh, PA, USA, 2017.

[8] Nick Hawes, Christopher Burbridge, Ferdian Jovan, Lars Kunze, Bruno Lacerda, Lenka Mudrova, Jay Young, Jeremy Wyatt, Denise Hebesberger, Tobias Kortner, Rares Ambrus, Nils Bore, John Folkesson, Patric Jensfelt, Lucas Beyer, Alexander Hermans, Bastian Leibe, Aitor Aldoma, Thomas Faulhammer, Michael Zillich, Markus Vincze, Eris Chinellato, Muhannad Al-Omari, Paul Duckworth, Yiannis Gatsoulis, David C. Hogg, Anthony G. Cohn, Christian Dondrup, Jaime P. Fentanes, Tomas Krajnik, Joao M. Santos, Tom Duckett, and Marc Hanheide. "The STRANDS Project: Long-Term Autonomy in Everyday Environments". In: *IEEE Robotics Automation Magazine* 24.3 (2017).

[9] Lenka Mudrová, Bruno Lacerda, and Nick Hawes. "Partial Order Temporal Plan Merging for Mobile Robot Tasks". In: *Proc. of the 22nd European Conf. on Artificial Intelligence (ECAI)*. The Hague, Netherlands, 2016.

[10] Bruno Lacerda, David Parker, and Nick Hawes. "Nested Value Iteration for Partially Satisfiable Co-Safe LTL Specifications (Extended Abstract)". In: *AAAI Fall Symposium on Sequential Decision Making for Intelligent Agents (SDMIA)*. Arlington, Virginia, USA, 2015.

[11] Bruno Lacerda, David Parker, and Nick Hawes. "Optimal Policy Generation for Partially Satisfiable Co-Safe LTL Specifications". In: *Proc. of the 24th Int. Joint Conf. on Artificial Intelligence (IJCAI)*. Buenos Aires, Argentina, 2015.

[12] Jaime Pulido Fentanes, Bruno Lacerda, Tomáš Krajník, Nick Hawes, and Marc Hanheide. "Now or later? Predicting and maximising success of navigation actions from long-term experience". In: *Proc. of the 2015 IEEE Int. Conf. on Robotics and Automation (ICRA)*. Seattle, WA, USA, 2015.

[13] Lenka Mudrová, Bruno Lacerda, and Nick Hawes. "An Integrated Control Framework for Long-Term Autonomy in Mobile Service Robots". In: *Proc. of the 7th European Conf. on Mobile Robotics (ECMR)*. Lincoln, United Kingdom, 2015.

[14] Bruno Lacerda, David Parker, and Nick Hawes. "Optimal and dynamic planning for Markov decision processes with co-safe LTL specifications". In: *Proc. of the 2014 IEEE/RSJ Int. Conf. on Intelligent Robots and Systems (IROS)*. Chicago, IL, USA, 2014.

[15] Bruno Lacerda and Pedro U. Lima. "On the Notion of Uncontrollable Marking in Supervisory Control of Petri Nets". In: *IEEE Transactions on Automatic Control* 59.11 (2014).

[16] Bruno Lacerda, David Parker, and Nick Hawes. "Optimal Motion Planning for Markov Decision Processes with Co-Safe Linear Temporal Logic Specifications". In: *31st Workshop of the UK Planning & Scheduling Special Interest Group (PlanSIG)*. Edinburgh, Scotland, UK, 2014.

[17] Bruno Lacerda and Pedro U. Lima. "LTL-Based Decentralized Supervisory Control of Multi-Robot Tasks Modelled as Petri Nets". In: *Proc. of the 2011 IEEE/RSJ Int. Conf. on Intelligent Robots and Systems (IROS)*. San Francisco, CA, USA, 2011.

[18] Bruno Lacerda and Pedro U. Lima. "Designing Petri Net Supervisors from LTL Specifications". In: *Proc. of Robotics: Science and Systems VII (RSS)*. Los Angeles, CA, USA, 2011.

[19] Bruno Lacerda and Pedro U. Lima. "Designing Petri Net Supervisors for Multi-Agent Systems from LTL Specifications (Extended Abstract)". In: *Proc. of the 10th Int. Conf. on Autonomous Agents and Multi-Agent Systems (AAMAS)*. Taipei, Taiwan, 2011.

[20] Bruno Lacerda, Pedro U. Lima, Javi Gorostiza, and Miguel A. Salichs. "Petri Net Based Supervisory Control of a Social Robot with LTL Specifications". In: *Proc. of the 11th Int. Conf. on Mobile Robots and Competitions*. Lisbon, Portugal, 2011.

[21] Bruno Lacerda and Pedro U. Lima. "Petri Nets as an Analysis Tool For Data Flow in Wireless Sensor Networks". In: *Proc. of the 1st Portuguese Conf. on Wireless Sensor Networks (CNRS)*. Coimbra, Portugal, 2011.

[22] Bruno Lacerda and Pedro U. Lima. "LTL Plan Specification for Robotic Tasks Modelled as Finite State Automata". In: *AAMAS 2009 Workshop on Agent Design: Advancing from Practice to Theory (ADAPT)*. Budapest, Hungary, 2009.

[23] Bruno Lacerda and Pedro U. Lima. "Linear-Time Temporal Logic Control of Discrete Event Models of Cooperative Robots". In: *Journal of Physical Agents* 2.1 (2008).