

# Matthew Budd

PhD Student in Robotics at the University of Oxford

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👤 Matthew Budd

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## Research Interests

Sequential decision-making under uncertainty, with a focus on meta-reasoning (reasoning agents with time and resource constraints, reasoning in non-stationary environments), Bayesian reinforcement learning, Markov decision process (MDP) safe exploration, and deployment on robotic platforms.

## Education

### DPhil in Robotics and Machine Learning

*University of Oxford*

2020 – 2024 📅

*Oxford* 📍

- Supervised by Prof. Nick Hawes and Dr. Bruno Lacerda (Goal-Oriented Long-Lived Systems lab, Oxford Robotics Institute).
- DPhil Research Studentship supported by an Amazon Web Services Lighthouse Scholarship.

### Master of Engineering in Engineering Science

*Pembroke College, University of Oxford*

2016 – June 2020 📅

*Oxford* 📍

- First class (average 81%, 87% for Master's project). Placed 5th in a cohort of ~160 students.
- MEng research project: “**Safe Planning for Markov Decision Processes with Unknown State Features**”. Proposed and analysed a novel MDP safe exploration algorithm, which outperformed the state of the art and generalised the class of model that could be safely explored. Available: [matthew-budd.com/static/doc/M\\_Budd\\_Thesis.pdf](https://matthew-budd.com/static/doc/M_Budd_Thesis.pdf)
- Awards: recipient of the Head of Department's Prize for Excellent Performance (2020), the Paul Martins - BP Scholarship in Engineering (2019), Gibbs Prize - Practical (2017), college Scholarships (2017, 2018, 2019), and an IET Diamond Jubilee Scholarship.

## Research Experience

### PhD field research / robotic trial experience

2021 – 📅

*Working with a number of robot platforms to carry out experiments in the real world.*

- Field trial for HUDSON project (below) – 4 weeks total deploying underwater robots and running experiment regimes at Loch Ness in Scotland, in adverse conditions and fighting hardware issues.
- 3-day safe exploration evaluation in underground bunker setting using a Boston Dynamics Spot. Responsible for experiment planning and monitoring/debugging system components on-the-fly.
- Demonstrated with the Spot robot at UK Atomic Energy Establishment “RACE” robotics test facility in Culham, as part of the Robotics and AI in Nuclear programme grant.

### Research assistant

July – October 2020 📅

*Autonomous planning - HUDSON project, [orcahub.org/engagement/partnership-fund/hudson](https://orcahub.org/engagement/partnership-fund/hudson)*

- Main researcher on the Oxford team, I was responsible for the research, design and implementation of a novel autonomous underwater vehicle (AUV) planning framework.
- First system to enable retrieval of data from underwater sensor networks under high uncertainty.
- Took a lead role in coordinating work packages between teams of researchers at several institutions.

### RoboCup @Home League

2019 – 2022

*Team ORIon: [ori.ox.ac.uk/student-teams/team-orion/](https://ori.ox.ac.uk/student-teams/team-orion/)*

*Sydney, Australia 📅*

- **Manipulation sub-team leader and acting team leader** for 2022 RoboCup (Thailand) [link].
  - Overhauled manipulation & simulation system, assigned work packages to the 3-person sub-team.
  - Improved team-wide processes and managed the whole team as acting leader at the competition.
  - Researched and implemented robot manipulation behaviours for the Toyota HSR platform.
- 2019 (Sydney): design/implementation of manipulation behaviours, network/hardware debugging.

### MEng 3rd-year group design project, 3-person team

October 2018 – May 2019 📅

**“A New Beam-Profile Monitor for the Large Hadron Collider at CERN”**

- Research and design development for a proposed cutting-edge proton beam imaging instrument.
- Optimised the design of high-speed gas jet apparatus with a GPU-accelerated simulation regime.
- Final technical presentation to Cern LHC Beam Instrumentation Group in Geneva.

## Publications

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1. **Stephens, A., Budd, M.** (*joint first authorship*), Staniaszek, M., Casseau, B., Duckworth, P., Fallon, M., Hawes, N. & Lacerda, B. (2024, August). Planning Under Uncertainty for Safe Robot Exploration using Gaussian Process Prediction. *Autonomous Robots*.
2. **Budd, M.,** Lacerda, B., & Hawes, N. (2024, February). Stop! Planner Time: Metareasoning for Probabilistic Planning Using Learned Performance Profiles. *AAAI Conference on Artificial Intelligence*.
3. **Budd, M.,** Duckworth, P., Hawes, N., & Lacerda, B. (2023, March). Bayesian reinforcement learning for single-episode missions in partially unknown environments. *6th Annual Conference on Robot Learning (CoRL)*.
4. **Budd, M.,** Salavasidis, G., Kamarudzaman, I., Harris, C. A., Phillips, A. B., Hawes, N., Duckworth, P., & Lacerda, B. (2022, October). Probabilistic Planning for AUV Data Harvesting from Smart Underwater Sensor Networks. *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*.
5. **Budd, M.,** Duckworth, P., Hawes, N., & Lacerda, B. (2021, August). Mission Planning in Unknown Environments as Bayesian Reinforcement Learning. *IJCAI'21 Workshop on Robust and Reliable Autonomy in the Wild (R2AW)*.
6. **Budd, M.,** Lacerda, B., Duckworth, P., West, A., Lennox, B., & Hawes, N. (2020, October). Markov Decision Processes with Unknown State Feature Values for Safe Exploration using Gaussian Processes. *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*.

## Teaching

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### Teaching Assistant / Programme Designer

March 2022 📅

*AIMS Centre for Doctoral Training Robotics Course*

- Improved the documentation, design and administration of a 4-day course which teaches mobile robotics to ~ 12 doctoral students. Taught on the course alongside 1 other TA.

ORI Robocup @Home League, team training

- Teaching assistance for two short courses introducing new graduate and undergraduate team members to ROS, software development best practices and Team ORION's software stack.

## Technical Skills

### Research

- Confident with Python, NumPy, C++, ROS, Git, L<sup>A</sup>T<sub>E</sub>X, deep RL frameworks (OpenAI Gym, Stable Baselines 3).
- Working knowledge of ML DevOps (Weights & Biases), PyTorch, MATLAB, Simulink, containerisation (Docker), GPU-accelerated (CUDA) programming, cluster and cloud computing (AWS, Slurm).
- Experiment design, robotic trial skills.

### Systems Engineering

- Linux, web development, mechanical & electrical CAD and prototyping, embedded (microcontroller, FPGA) systems, real-time OSs (FreeRTOS), databases (SQL), communications (5G NR, IPv4/v6, IEEE 802.15), industrial computer vision systems, basic-level SysAdmin & cryptography,
- Robotic research platforms: Boston Dynamics Spot, Clearpath Jackal, ecoSUB, Toyota Human Service Robot (HSR).

## Industrial Experience

### Technology Scholar at Cambridge Consultants Ltd.

July – September 2019 📅

Summer internship placement in a software and electronics group

Cambridge

- **Software engineer** on a medical inhaler test rig project.
  - Design, development and testing of embedded software (embedded C++ and a FreeRTOS-based framework) and the front-end user interface (JavaScript and Python with a Tornado webserver).
  - Responsible for modelling elastic light scattering from microscopic vapour particles. Designed and ran a CELES ([github.com/disordered-photonics/celes](https://github.com/disordered-photonics/celes)) simulation regime with CUDA.

### Control Engineering Intern at Archangel Lightworks

June – August 2018

Summer internship placement in a satellite optical communications start-up Harwell, Oxfordshire 📅

- **Pointing, Acquisition and Tracking (PAT) Prototype Development** for Free-Space Optical Comms.
  - Completed a literature review and requirements identification/justification for the PAT system.
  - Produced a project plan, cost analysis and interface definitions between systems.
  - Carried out integration of multiple hardware and software components (a custom FPGA-based controller, actuators, IMU/GPS, and imaging devices) to prototype a high-speed PAT system.

### Micro-Intern at Ensoft Ltd.

December 2017

Week-long internship, adding functionality to the Ensoft intranet

Harpden 📅

- **Python web-app development with Django**, for the front- and back-end of the site.
  - Added new functionality to automatically handle desk allocation changes by updating large IP phone configuration files and mailing lists, and front-end interface design work for these features.

### Technology Scholar at Cambridge Consultants Ltd.

September 2015 – July 2016, Summer 2017

Gap-year placement and summer internship in a software and electronics group

Cambridge 📅

- **Embedded Low-Power Communications Engineer** and Linux Kernel Software Developer.
  - Network architecture research and design for full-fledged IPv6 communications on IoT devices.
  - Designed and implemented: Linux kernel-space software in C including kernel modules and adding functionality to the kernel network stack, user-space software in C and Python, embedded software in C for Cortex-M microcontrollers. Cross-compiled custom designed Embedded Linux distributions with Yocto and OpenEmbedded.

- **Electronics and Low-Level Software Lead** on an internal cross-disciplinary robotics project.
  - Successfully delivered and presented a prototype robot arm system to be demonstrated at a company-wide meeting, overcoming significant time/budget constraints.
  - Took a lead role in the engineering design process, from requirements specification onwards.
  - [cambridgeconsultants.com/insights/robots-from-golden-fairy-to-iron-serf](https://cambridgeconsultants.com/insights/robots-from-golden-fairy-to-iron-serf)