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Christopher Edwin Mower

Google Scholar (h-index 5, i10-index 2) cmower LinkedIn Website
Field of Specialization: Human-Robot Interaction, Reinforcement Learning, Robot Learning, Surgical Robotics.

Education

University of Edinburgh, *PhD Informatics* Sep 2021, **Edinburgh, UK**
Thesis: An Optimization-based Formalism for Shared Autonomy in Dynamic Environments
Supervised by Professor Sethu Vijayakumar FRSE. Affiliated with the Edinburgh Centre for Robotics

Imperial College London, *MSc Computing (Visual Information Processing)* Aug 2016, **London, UK**
Dissertation: Objective Assessment of Surgical Dexterity
Supervised by Dr Benny Lo.

University of Manchester, *MSc Applied Mathematics with Numerical Analysis* Aug 2015, **Manchester, UK**
Dissertation: Shrinking For Restoring Definiteness
Supervised by Professor Nicholas J. Higham FRS, and Dr Craig Lucas (NAG).

University of Sheffield, *BSc Mathematics* Aug 2012, **Sheffield, UK**

Experience

Huawei Technologies R&D, *Research Scientist* Aug 2023—, **London, UK**
- Work in the Reinforcement Learning team with Professor Haitham Bou-Ammar.
- Working at the intersection of AI and robotics. Also involved with recruitment, procurement, and supervision of interns.

Balgrist University Hospital, *Visiting Scholar* Summer 2023, **Zürich, Switzerland**
- Worked in the Research in Orthopedic Computer Science group with Prof. Dr. Philipp Fürnstahl, and supported by GEPF (below).
- Coordination with clinicians and engineers for cadaver specimen trials.
- Developed approaches for dual-arm collaborative surgical robotics applied to endoscopic lumbar discectomy.

KU Leuven, *Visiting Scholar* Spring 2023, **Leuven, Belgium**
- Worked in the Robot-Assisted Surgery group with Prof. Emmanuel Vander Poorten, and supported by GEPF (below).
- Developed approaches for keyhole surgery, utilizing visual servoing, contact rich manipulation, and optimization-based control.

King's College London, *Research Associate for Surgical Robot Control* May 2022—Aug 2023, **London, UK**
- Worked in the RViM Lab with Professor Christos Bergeles, and CAI4CAI group with Professor Tom Vercauteren.
- Robotic surgery, human-robot interaction, imitation learning, and shared autonomy.
- Developed and implemented OpTaS library; a task specification Python library for optimal control.
- Successful funding application.
- Collaborated on the European Union Horizon 2020 FAROS project.
- Visited KU Leuven, Belgium to integrate our HRI system into a novel dual arm setup for pedicle screw fixation.
- Supervised several masters projects and mentored PhD students. Additionally, King's Undergraduate Research Fellowship supervisor.
- Public engagement: demonstrated work at New Scientist Live, ExCeL London 2022 and Royal Society, London.
- Attended surgical summer school and other workshops/training sessions, and observed live surgery.

University of Edinburgh, *Research Associate* Sep 2021—May 2022, **Edinburgh, UK**
- Worked in the SLMC Group with Professor Sethu Vijayakumar FRSE.
- Shared control for sequencing hybrid multi-contact, dual-arm interactions.
- Developed/implemented the ROS-PyBullet Interface; bridges ROS and PyBullet (a reliable contact simulator).
- Collaborated on the European Union Horizon 2020 project HARMONY and ORCA Hub.
- Contributed to the Smart Factory projects in collaboration with the Kawada Group, Japan.
- Affiliated with The Alan Turing Institute.
- Lab demonstrator: supervisor for the course System Design Project on HRI and UX. Marking assignments, group assessments, etc.

Numerical Algorithms Group, *Numerical software developer intern* Jun 2014—Oct 2014, **Manchester, UK**
- Analyzed and implemented the routine `G02ANF` in FORTRAN that computes a correlation matrix, subject to preserving a leading principle submatrix by applying the smallest uniform perturbation of the remainder of the approximate input matrix.
- Authored documentation and example routines for `G02ANF`, and collaborated with NAG personnel on the development of several unit and functional tests.
- Routine included in the Mark 25 NAG C and FORTRAN Libraries, and NAG Toolbox *for MATLAB*. Acknowledged as a code contributor to the NAG Library—a commercial-grade library mainly used by major banks and insurance firms.

University of Manchester, *Research intern* May 2014—Oct 2014, **Manchester, UK**
- Implemented a Python method that computes a unit triangular matrix with prescribed singular values, unit tests, and reviewed related code. Project supervised by Professor Nicholas J. Higham FRS.

Scholarships, Awards, and Memberships

- **King's Global Engagement Partnership Fund (GEPF) Award**, successfully applied and awarded funding to support a collaboration and visiting positions at KU Leuven, Belgium, and Balgrist University Hospital, Switzerland.
- **First prize for best poster** on *Non-prehensile Dual Arm Manipulation* at the 5th IEEE UK & Ireland RAS Conference 2022.
- **First prize** for "*Greatest Potential For Positive Impact*", Robots for Resilient Infrastructure International Challenge, UK, 2017.
- **iCASE Studentship Award**, PhD funding, University of Edinburgh, The Costain Group, and UKRI-EPSRC, 2016.
- Member of the Institute of Electrical and Electronics Engineers (IEEE).
- **Industrial Bursary Award**, University of Manchester, Numerical Algorithms Group (NAG), 2015.
- Travel grant from London Mathematical Society for *Prospects in Mathematics*, University of Oxford, 2014.

Publications

Journal:

- H. Tian, M. Huber, **C. E. Mower**, Z. Han, C. Li, X. Duan, C. Bergeles, *Semi-Autonomous Laparoscopic Robot Docking with Learned Hand-Eye Information Fusion*, [under review] **IEEE TBME**, 2024.
- M. Huber, H. Tian, **C. E. Mower**, C. Budd, A. Davoodi, S. Vafadar, A. Harle, E. Vander Poorten, G. Morel, C. Bergeles, T. Vercauteren, *Hydra: Stereo Imaging Approach to Unified Vision-based Robot Calibration*, [under review] **IEEE TBME**, 2024.
- M. Huber, **C. E Mower**, S. Ourselin, T. Vercauteren, C. Bergeles, *LBR-Stack: ROS 2 and Python Integration of KUKA FRI for Med and IIWA Robots*, [under review] **JOSS**, 2024.

Conference:

- H. Tian, M. Huber, **C. E. Mower**, Z. Han, C. Li, X. Duan, C. Bergeles, *Excitation Trajectory Optimization for Dynamic Parameter Identification Using Virtual Constraints in Hands-on Robotic System*, **IEEE ICRA**, 2024.
- **C. E. Mower**, M. Huber, H. Tian, A. Davoodi, E. Vander Poorten, T. Vercauteren, C. Bergeles, *Vision and Contact based Optimal Control for Autonomous Trocar Docking*, **CRAS**, 2023.
- C. Budd, J. Qiu, O. J. Maccormac, M. Huber, **C. E. Mower**, M. Janatka, T. Trotouin, J. Shapey, M. Bergholt, T. Vercauteren, *Deep Reinforcement Learning Based System for Intraoperative Hyperspectral Video Autofocusing*, **MICCAI**, 2023.
- **C. E. Mower**, J. Moura, N. Zamani Behabadi, S. Vijayakumar, T. Vercauteren, C. Bergeles, *OpTaS: An Optimization-based Task Specification Library for Trajectory Optimization and Model Predictive Control*, **IEEE ICRA**, 2023.
- A. Mutaz Zeidan, Z. Xu, **C. E. Mower**, H. Wu, Q. Walker, O. Ayoade, N. Cotic, J. Behar, S. Williams, A. Arujuna, Y. Noh, R. J. Housden, K. Rhode, *Design and Development of a Novel Force-Sensing Robotic System for the Transseptal Puncture in Left Atrial Catheter Ablation*, **IEEE ICRA**, 2023.
- **C. E. Mower**, T. Stouraitis, J. Moura, C. Rauch, L. Yan, N. Zamani Behabadi, M. Gienger, T. Vercauteren, C. Bergeles, S. Vijayakumar, *ROS-PyBullet Interface: A Framework for Reliable Contact Simulation and Human-Robot Interaction*, **CoRL**, 2022 [Links: paper, video, code].
- **C. E. Mower**, J. Moura, T. Stouraitis, S. Vijayakumar, *Shared Autonomy for Enhancing Trajectory Optimization*, **IEEE ICRA SAPHRI Workshop**, 2022 [Links: paper, talk, poster, workshop].
- **C. E. Mower**, J. Moura, S. Vijayakumar, *Skill-based Shared Control*, **R:SS**, 2021 [Links: paper, video, talk, poster].
- **C. E. Mower**, J. Moura, A. Davies, S. Vijayakumar, *Modulating Human Input for Shared Autonomy in Dynamic Environments*, **IEEE RO-MAN**, 2019 [Links: paper, pdf].
- **C. E. Mower**, W. Merkt, S. Vijayakumar, *Comparing Alternate Modes of Teleoperation for Constrained Tasks*, **IEEE CASE**, 2019 [Links: paper, pdf, preprint, video].
- W. Merkt, Y. Yang, T. Stouraitis, **C. E. Mower**, M. Fallon, S. Vijayakumar, *Robust Shared Autonomy for Mobile Manipulation with Continuous Scene Monitoring*, **IEEE CASE**, 2017 [Links: paper, pdf, video, outreach demo, press (BBC), press (Made In Leeds TV)], **First prize for "*Greatest potential for Positive Impact*"**.

Additionally, I and others are preparing a workshop proposal.

Supervision and mentoring

I have been involved with project proposal and supervision for several PhD, MSc, and BSc students. Additionally, I have contributed significantly as a mentor to a number of PhD students (e.g. weekly progress meetings, project collaboration).

Supervision

- H. Yu, supervising internship at Huawei Technologies R&D.
- C. Dave, BSc student, King's College London, supervised summer project funded by King's Undergraduate Research Fellowship.
- A. Esfandiari, PhD student, King's College London, supervised MSc thesis.
- S. Zhang, MSc student, King's College London, supervised MSc thesis.
- R. Liu, MSc student, King's College London, supervised MSc thesis.
- H. Wang, MSc student, King's College London, supervised MSc thesis.

Mentoring

- M. Huber, King's College London, PhD student.
- H. Tian, Beijing Institute of Technology, exchange PhD student at King's College London.
- A. Mutaz Zeidan, King's College London, PhD student.
- A. Davoodi, KU Leuven, PhD student.
- M. Aoyama, University of Edinburgh, PhD student.
- R. Mon-Williams, University of Edinburgh, PhD student.

Skills

- **Programming**: Most fluent in Python, then C++, MATLAB, and FORTRAN. Some experience with Lisp, and Lua.
- **Hardware**: Experience developing/implementing demonstrations and experiments using the KUKA LBR Med Arm, KUKA LWR Arm, Kawada Nextage humanoid, Clearpath Husky UGV, xArm robot, Universal Robot 5 (UR5) Arm, and Robotiq 3-finger adaptive gripper. Additionally, experience setting up and integrating several sub-systems: (i) human interfaces such as the Haption Virtuose 6D and Touch X haptic devices, several joysticks, and 3DConnexion SpaceMouse, (ii) perception sensors such as the ASUS Xtion RGBD-camera, and Bumblebee2 FireWire stereo vision camera, and (iii) motion tracking systems such as Vicon.
- **Operating systems**: Most experienced using Ubuntu, Windows, and Mac OS.
- **Libraries, packages, and frameworks**: AprilTags, Black, CasADi, CVXOPT, Eigen, Geomagic Design X, Git, Gurobi, Ipopt, Knitro, LAPACK, LCM, Matplotlib, MoveIt, NAG Library, Numpy, Onshape, OSQP, Gym Library, OpenCV, Pandas, PyBullet, PyGame, PyTorch, ROS/ROS2, SNOPT, StableBaselines3, Scikit-learn, Scipy, and CoppeliaSim (V-REP).
- **Financial management, and fund application**: able to handle financial resources, prioritize tasks effectively, and make informed decisions that align with organizational goals.
- **Document preparation and code editing**: Visual Studio Code, LaTeX, Emacs.
- **Time management**: Org-mode (for Emacs).
- **Soft skills**: mentoring, public speaking, self-motivated, and open to feedback and idea exchange.

Responsibilities

- Reviewer: RA-L, ICRA, IROS, CASE.
- Vice President for SIAM Student Chapter, University of Manchester, Sept 2014 — Sept 2015.
- Session chair, SIAM Student Chapter Conference, 2014, 2015.
- Program Representative for MSc Group, University of Manchester, Sept 2014 — Sept 2015.
- School of Mathematics Board Member, University of Manchester, Sept 2014 — Sept 2015.
- Team Captain for University of Sheffield Badminton Club, University of Sheffield, Sept 2010 — Sept 2012.

Open Source Projects

Alongside research, I am an advocate for high quality open source projects.

- **OpTaS** (lead) [71 stars]: an optimization-based task specification library for trajectory optimization and model predictive control. *Presented at ICRA 2023.*
- **ROS-PyBullet Interface** (lead) [67 stars]: a framework for reliable contact simulation and HRI. *Presented at CoRL 2022.*
- **LBR Stack** (co-lead) [94 stars]: ROS1/2 packages for the KUKA LBR (Med/IIWA). *Submitted to the Journal of Open Source Software.*
- **pyFRI** (lead) [16 stars]: This project provides Python bindings for the FRI Client SDK C++ for KUKA IIWA/Med LBR robot arms. *Submitted to the Journal of Open Source Software.*
- **ArUCo Markers** (lead) [12 stars]: A compact Python package for handling ArUCo markers.
- **Spatial CasADi** (lead) [7 stars]: Spatial transformation library for CasADi Python.
- **EXOTica** (main contributor) [145 stars]: an optimization toolset for prototyping/benchmarking motion planning and control.
- Contributor to popular projects: bullet3, PythonRobotics, and urdf2casadi.

Training

- Surgical and Interventional Engineering Summer School 2022 at Guy's and St. Thomas' Hospital, King's College London.
- King's NeuroLab Teaching Sessions: Posterior lumbar spine approaches, June 2022.
- First aid at work, St. Johns Ambulance.
- National Pool Lifeguard Qualification, Royal Life Saving Society.