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Christopher Edwin Mower

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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

Balgrist University Hospital, *Visiting Scholar* — Summer 2023, **Zürich, Switzerland**
- Work in the Research in Orthopedic Computer Science (ROCS) group with Prof. Dr. Philipp Fürnstahl.
- Implementing methods for keyhole surgery into realistic operating theater setup for cadaver experiments.
- Supported by King's Global Engagement Partnership Award, please see Scholarships and Awards section below.

KU Leuven, *Visiting Scholar* — Spring 2023, **Leuven, Belgium**
- Worked in the Robot-Assisted Surgery group with Prof. Emmanuel Vander Poorten.
- Developing automated approaches for keyhole surgery (demonstrated for Endoscopic Lumbar Discectomy) utilizing control, imitation learning, and image-based state estimation.
- Supported by King's Global Engagement Partnership Award, please see Scholarships and Awards section below.

King's College London, *Research Associate for Surgical Robot Control* — May 2022—, **London, UK**
- Work in the RViM Lab with Dr Christos Bergeles, and CAI4CAI group with Professor Tom Vercauteren.
- Robotic surgery, human-robot interaction, imitation learning, and shared autonomy.
- Developed and implemented OpTaS library; task specification Python library for optimal control.
- Collaborating on the European Union Horizon 2020 project FAROS.
- Visited KU Leuven, Belgium to integrate our HRI system into a novel dual arm setup for pedicle screw fixation.
- Supervised several masters projects.
- Demonstrated work to public at New Scientist Live, ExCeL London 2022.
- 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.

University of Edinburgh, *Lab demonstrator* — Jan 2019—Jun 2020, **Edinburgh, UK**
- Supervisory role 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.

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 and Awards

- **King's Global Engagement Partnership Fund Award**, funding to support a collaboration and visiting positions at KU Leuven, Belgium, and Balgrist University Hospital, Switzerland. Visits planned Mar-Jul 2023 and will include cadaver studies.
- **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.
- **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

- **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, 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*"**.

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, 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, Scikit-learn, Scipy, and CoppeliaSim (V-REP).
- **Financial management, and fund application**: able to handle financial resources, prioritise tasks effectively, and make informed decisions that align with organisational goals.
- **Document preparation and code editing**: LaTeX, Emacs, and Visual Studio Code.
- **Time management**: Org-mode (for Emacs).
- **Soft skills**: mentoring, public speaking, self-motivated, and open to feedback and idea exchange.

Open Source Projects

- **ArUCo Markers** (lead): A compact Python package for handling ArUCo markers.
- **OpTaS** (lead): an optimization-based task specification library for trajectory optimization and model predictive control (*will be presented at ICRA 2023*).
- **Spatial CasADi** (lead): Spatial transformation library for CasADi Python.
- **ROS-PyBullet Interface** (lead): a framework for reliable contact simulation and human-robot interaction (*presented at CoRL 2022*).
- **LBR FRI ROS Stack** (contributor): ROS1/2 packages for the KUKA LBR (Med/IIWA).
- **EXOTica** (contributor): an extensible optimization toolset for prototyping and benchmarking motion planning and control.
- Contributor to popular projects: bullet3, PythonRobotics, and urdf2casadi.

Responsibilities

- Reviewer: RA-L, ICRA, IROS, CASE.
- Mentoring PhD student, and master student supervision.
- 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.

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.

Additional

- Personal interests: Badminton (competed at county and university level, coaching experience), Guitar.