Sam Wilcock

Researcher in Construction Robotics

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Education

2020–2025 **PhD in Civil Engineering**, *University of Leeds*, UK
Chair of Structures & Architecture. Researching manipulator robot arms for structural assembly, digital fabrication, and parametric design integration for shell structures.

2018–2019 **MSc(Eng) Mechatronics & Robotics**, *University of Leeds*, UK
Focus on control systems, manipulator arms, and biomimetic optimisation. Thesis on genetic algorithms for bipedal robots.

2011–2015 **BSc Mechanical Engineering**, *University of Nottingham*, UK
1-year exchange in Kuala Lumpur, Malaysia (2012–13).

Employment

2024–Present **Assegnista di Ricerca/Research Fellow**, *Politecnico di Milano*, Italy
Researching the use of robot manipulator arms for the manufacture and assembly of complex curved surfaces.

2015–2019 **Self-employed Construction Operative**
Designed and built systemised sports courts across UK, France, and Germany.

Teaching & Supervision

2025 **MSc Project Supervisions**
Supervising master's level final dissertation projects in robotics simulation, and circular economy driven design.

2022 **Module Designer – LISS1052 Digital Design and Fabrication**
Full module design, delivery and assessment for international students over 1 month alongside 2 colleagues. Focus on parametric design of architectural shells, digital manufacture and assembly culminating in the realisation of a 1.7m high shell building.

2022 **BSc Project Supervision – Parametric structural design**
Aided in supervising a final BSc project in parametric structural design, planning regular meetings and suggesting direction of research.

2021–2024 **TA – MECH1310 Mechanics for Mechatronics**
Developing and delivering example class materials on solid mechanics, managing a team of PGR demonstrators, running lab sessions and assessment.

2021–2024 **TA – MECH1010 Computers in Engineering Analysis**
Assisting with students in a flipped classroom approach to learning engineering programming with Matlab and Arduino.

2021–2024 **TA – MECH2300 Design & Manufacture**
Delivering material and answering queries in design studios, working with Solidworks CAD software.

Funding Awards

2024 Rob|Arch Conference – Best student scholarship

2023 £2,000 Leeds Internationalisation fund (Venice Biennale di Architettura)

2020–2024 EPSRC DTP Scholarship (£17,668 p/a + £3,000 p/a departmental uplift scholarship)

2018 £2,000 Head of School Scholarship (MSc support)

Administrative Responsibilities

2020–Present Chair – Robotics at Leeds PGR Network Committee

Outreach & Impact

2025 Guest Lecturer – Airlangga University, Indonesia

2023 Invited Speaker – Institute for Safe Autonomy, York

2023 Presenter – IWSS, Turin; ICRA2023, London; Venice Biennale

2022 Presenter – ICSA2022, Aalborg; ETH Zürich; Be Curious (Leeds)

Professional Memberships

2025–Present COST CA21103 – Implementation of Circular Economy in the Built Environment (CircularB)

2024–Present Fellowship (D2), Advance HE

2021–Present Member, IASA; IASS; IEEE RAS

Research Visits

Jan 2024 Politecnico di Milano – Research on collaborative robots

Publications

2025 Wilcock, Sam and Ornella Iuorio (2025). "Kinetic Harlequin: An Interactive Kinetic Sculpture Simulating Nature through Discrete Mechanisms". In: *Metamorphosis. Transforming Italian Architecture.* ISBN: 979-12-5486-522-4.

Wilcock, Sam and Ornella Iuorio (2025). "Robotic Manipulators as Advanced Manufacturing Agents for Laser-Cut Construction Systems". In: *AM Perspectives 2: Additive Manufacturing and Advanced Manufacture.*

Wilcock, Sam and Ornella Iuorio (2025). "Towards Automating the Workflow for Design, Manufacturing, and Assembly Process Feedback of Discrete Panel Structures". In: *REstructure Rematerialize Rethink Reuse.* CRC Press / Balkema / Antwerp, Belgium.

Wilcock, Sam, Ivan Smirnov, and Ornella Iuorio (2025). "Neural Network Tree Identification from Street View Images to Estimate CO2 Sequestration". In: *Evisioning the Futures: Designing and Building for People and the Environment.*

2024 Iuorio, Ornella, Sam Wilcock, and Emil Korkis (2024). "Design for Deconstruction Through Digital Fabrication of Thin Spatial Systems". In: *4th International Conference "Coordinating Engineering for Sustainability and Resilience" & Midterm Conference of CircularB "Implementation of Circular Economy in the Built Environment".* Ed. by Viorel Ungureanu et al. Cham: Springer Nature Switzerland, pp. 262–272. ISBN: 978-3-031-57800-7. DOI: 10.1007/978-3-031-57800-7_24.

Wilcock, Sam, Mehmet R. Dogar, and Ornella Iuorio (2024). “Methodology for Stability Assessment of Discretised Shell Structures During Robotic Assembly”. In: *Shell and Spatial Structures*. Ed. by Stefano Gabriele et al. Cham: Springer Nature Switzerland, pp. 472–482. ISBN: 978-3-031-44328-2. DOI: 10.1007/978-3-031-44328-2_49.

Wilcock, Sam, Han Fang, et al. (2024). “Integrating R-funicularity, Local Stability and Inter-Panel Constraint Assessment for Discrete Timber Shell Construction Design”. In: *Structures* 64, p. 106592. ISSN: 2352-0124. DOI: 10.1016/j.istruc.2024.106592.

2022 Wilcock, Sam, Jordan H. Boyle, et al. (2022). “Automated Robotics Agents for Assembly-Aware Design of Shells”. In: *5th International Conference on Structures and Architecture*. CRC Press, pp. 1061–1068. DOI: 10.1201/9781003023555-127.

Research Statement

My academic interests lie primarily in the design and control of robotic systems for manipulation tasks. Through exploration of the architectural robotics literature and exposure to the field, I became interested in how we might use such robotics for actual structural applications. Whilst single task construction robots have been in use since at least the 1980s, they have been unadaptable, leading to the question of how we can make use of robots as more general tools. Manipulator arms in particular are often thought of as factory line devices, utilised for repetitive, single tasks to manufacture products; however their high dexterity, precision and repeatability makes them ideal candidates as multi-purpose construction agents. My research so far through my PhD has focused on this, and the application specifically to shell structures.

Shell structures offer a number of appealing benefits as designs, primarily their high material efficiency and strength over large areas, and through form-finding they can be designed to be loaded principally via membrane action which ensures unsupported stability once constructed. In order to design such structures to be built via robots, we have been exploring the integration of robot kinematics (reachability assessments) into parametric design software Grasshopper, to provide early stage design feedback on how feasible robot assembly is for a particular shell design. We have demonstrated the use of such reachability assessments as a parameter for the generative design of shells, bringing the robot into the design loop.

Another key driver of my work is reducing waste through reducing falsework, or scaffolding requirements. Other research is ongoing from different institutes on the assembly of segmented shell structures via robotics (e.g. Parascho and Adriaenssens Lightvault of 2020), however the focus has been mainly on the use of multiple robots to provide temporary supports during assembly. My work has explored the use of structural mechanics to further mitigate falsework requirements, using procedures such as the rigid block equilibrium method to predict stability and deflection in structures. By exploiting the local constraints applied by different panel joining styles, for example dovetail joints, and verifying stability with structural mechanics tools integrated again into parametric design software, we have designed and realised a section of a form-found shell which maintains local stability during assembly without scaffolding of any kind, instead making use of friction and cantilevering effects to remain located within predicted deflection bounds. Verification work is underway in Finite Element Analysis (FEA) software to verify predictions in these techniques.

In order to undertake my research, I have become highly proficient in the use of parametric design tool Grasshopper, bringing my programming experience from my education to write custom components and tools in C# and Python wherever necessary. This has proven extremely useful in my work designing shell structures and engineering data integrations between adjacent softwares. Some of my first work during my PhD candidacy was to design and link together the mechanical and electronic aspects of our Kuka manipulator arm. Having built the testbed, I created software tools to bring the kinematic analysis, path planning and control of the robot into Grasshopper. Where other plugins exist and allow control of robots (e.g. Kuka PRC), they generally simplify robot control to a to a one-directional flow into the design software, whereas through our work using the Robot Operating System (ROS) bidirectional data transfer is used, giving the designer feedback on error build up and allowing modifications during the assembly through the use of digital twin modelling of the construction processes. This has potential for application to further architectural fabrication fields including the generative manufacture of additively created structures.

My general proficiency with a wide range of software tools and programming languages (C, C++, C#, Python, Java, Golang), experience with digital fabrication mechanisms such as 3D printing and laser cutting, and a love of the use of mathematics for optimisation alongside a high capability for researching and learning new methods makes me a capable researcher. I would like to pursue a future taking the next steps with my research through expanding the integration of digital fabrication and robotic assembly into architectural designers' toolboxes, through application to a wider range of structures and generally making use of new technologies for augmentation of architectural design. In particular, the use of additive manufacture for the exploration of freeform geometries, and how mechatronic devices can both impact and become design agents inspire my current research direction, and I would be keen to further pursue new questions within the architectural robotics field.