+44 7375 926802
s.wilcock@leeds.ac.uk
http://samwilcock.xyz

SAM WILCOCK

ARCHITECTURAL ROBOTICS RESEARCHER

EDUCATION

2020 - PRESENT **PhD Candidate** in Civil Engineering, University of Leeds, UK

Chair of Structures & Architecture. Expected end date March 2024

Researching the use of manipulator robot arms for structural assembly, digital fabrication and integration into parametric design flows for segmented shell structures. Additionally use stability and deflection modelling for designing stable assemblies and mitigating formwork requirements.

2018 - 2019 **MSc(Eng)** Mechatronics & Robotics, University of Leeds, UK

Undertook a research driven masters with particular focus on manipulator arms, control systems and biomimetic optimisation. Culminated in a thesis on the use of genetic algorithms for control of biped walking robots.

2011 - 2015 **BSc** Mechanical Engineering, University of Nottingham, UK

1 year exchange in Kuala Lumpur, Malaysia (2012-13)

EMPLOYMENT

2015 - 2019 Self-employed sports court construction operative

Working with shareholders and clients on-site to design and build sports courts through systemised construction. Clients spanning UK, France, and Germany.

FUNDING AWARDS

2023 £2,000 award through Leeds Internationalisation fund

Awarded for materials and travel to Venice Biennale.

2020 - PRESENT UK Research Institute EPSRC DTP Scholarship

£17,668 p/a. for 3.5 years

Additional £3,000 p/a. through department scholarship.

2018 £2,000 Head of School Scholarship

Awarded for outstanding applicants to support MSc education.

TEACHING & SUPERVISION

2022 **Module Leader**: LISS1052 *Digital Design and Fabrication*

Full module design, delivery and assessment for international students over 1 month. 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**

Aided in supervising a final BSc project in parametric structural design, planning regular meetings and suggesting direction of research.

2021 - PRESENT **Teaching Assistant**: MECH1310 *Mechanics for Mechatronics and Robotics*

Developing and delivering example class materials on solid mechanics, managing a team of PGR demonstrators, running lab sessions and assessment.

2021 - PRESENT **Teaching Assistant**: MECH1010 *Computers in Engineering Analysis*

Assisting with students in a flipped classroom approach to learning engineering programming with Matlab and Arduino.

2021 - PRESENT **Teaching Assistant**: MECH2300 *Design & Manufacture*

Delivering material and answering queries in design studios, working with Solidworks CAD software.

ADDITIONAL RESPONSIBILITIES

2020 - PRESENT **Chair**, Robotics at Leeds PGR Network Committee

Organising monthly events, promoting engagement within the Leeds robotics community, and networking Civil Engineering across faculty. Elected chair in 2021.

OUTREACH & IMPACT

JULY 2023 **Invited speaker**, Institute for Safe Autonomy, University of York, UK

Talk on “Robotics on construction sites: assembly in cluttered human spaces”.

JUNE 2023 **Presenter,** Italian Workshop on Shell and Spatial Structures 2023. Turin, Italy

Talk on “Methodology for stability assessment of discretised shell structures during robotic assembly”

JUNE 2023 **Exhibitor**, International Conference on Robotics and Automation ICRA202, London, UK

Lead exhibitor for Uni. Leeds stand showcasing robotics work, managing a team of 10 members of staff and PGRs.

OUTREACH & IMPACT (CONT'D)

MAY 2023 **Presenter**, Venice Biennale Architettura collateral event, "Students as Researchers". Venice, Italy

Invited to design and present an architectural artifact in Venice to be displayed for the duration of the 2023 Biennale.

MARCH 2023 **Invited speaker,** A Pint of Robotics, Leeds, UK

JUNE 2022 **Presenter,** International Conference on Structures and Architecture 2022, Aalborg, Denmark

Talk on "Automated robotics agents for assembly-aware design of shells"

MAY 2022 **Presenter,** Future of Construction 2022, ETH Zürich, Switzerland

Poster presentation on "Transforming Construction Through Parametric Modelling and Robotic Assembly"

MAY 2022 **Outreach role,** Be Curious 2022, Leeds, UK

Delivered outreach activities demonstrating robotic construction to ~2000 children aged 2-17.

PROFESSIONAL MEMBERSHIPS

2021 - PRESENT International Association of Structures and Architecture (IASA)

2021 - PRESENT International Association for Shell and Spatial Structures (IASS)

2017 - PRESENT IEEE Robotics and Automation Society

Sam Wilcock

Architectural robotics researcher

PUBLICATIONS

ORCID 0000-0002-8353-6219

Wilcock, S, Dogar, M, Iuorio, O, (2023) *Methodology for stability assessment of discretised shell structures during robotic assembly*. To be published in: Lecture Notes in Civil Engineering. Springer. (Accepted)

Wilcock, S, Boyle, JH, Dogar, M, Iuorio, O, (2022) *Automated robotics agents for assembly-aware design of shells*. In: Structures and Architecture A Viable Urban Perspective? 5th International Conference on Structures and Architecture, 06-08 Jul 2022, Aalborg, Denmark. CRC Press, pp. 1061-1068. Doi: 10.1201/9781003023555-127

Sam Wilcock

Architectural robotics researcher

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 shells 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.

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 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 one-directional flow

into the design software, giving the designer feedback on error build up and allowing modifications during the assembly. 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 procedurally generated geometries and how mechatronic device use 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.