

DESIGN FOR 4D PRINTING

18th September 2023



Engineering and
Physical Sciences
Research Council



Design
for AM
NETWORK



Nottingham Trent
University

INTRODUCTION

This exciting online event is brought to you in collaboration with Dr Mahdi Bodaghi from Nottingham Trent University.

Our event will feature a lineup of expert speakers, all pioneers in the realm of 4D printing. Together, they will engage in panel discussions that offer a comprehensive global perspective on the profound impact of materials, design, and additive manufacturing (AM) on the behaviours of 4D printed objects. Moreover, you can anticipate gaining fresh insights into the art of design for 4D printing.

During this event, we'll delve into the latest advancements and cutting-edge technologies in smart materials, intelligent design practices, multi-physics modelling, and 3D/4D printing. We'll also explore the challenges and opportunities that lie ahead in the continued development of 3D/4D printed devices.

Host: Dr [Mahdi Bodaghi](#)

Senior Lecturer

Nottingham Trent University



Mahdi is an academic and innovator in Smart Materials, Metamaterials and 3D/4D Printing Technologies. His vast experience and research on smart materials/metamaterials and additive manufacturing have led him to co-found the 4D Printing Society and to co-edit the book series—Smart Materials in Additive Manufacturing. His research has resulted in the publication of over 225 scientific papers in prestigious journals as well as the presentation of his work at major international conferences.

AGENDA

Start	Finish	Presenter	Affiliation	Title of talk
10:00	10:10	Mahdi Bodaghi	Nottingham Trent University, UK	Introduction
10:10	10:35	Ali Zolfagharian	Deakin University, Australia	Crafting Tomorrow's Robotics by 4D Printing
10:35	11:00	Frédéric Demoly	Belfort-Montbéliard University of Technology, France	Challenges in Designing for 4D printing
11:00	11:10	Break		
11:10	11:35	Dimitrios Lamprou	Queen's University Belfast, UK	3D and 4D Printing Applications in Pharmaceuticals
11:35	12:00	Panel Discussion		
12:00	12:25	Moataz Attallah	University of Birmingham, UK	Additive of Manufacturing of Mechanical Metamaterials using Shape Memory and Superelastic Alloys
12:25	12:50	Charlie C.L. Wang	University of Manchester, UK	Optimization-Based Geometric Computing for Deformable Structures
12:50	13:00	Break		
13:00	13:25	Dennis Douroumis	University of Greenwich, UK	3D Printing for Pharmaceutical and Medical Applications
13:25	13:50	Panel Discussion		
13:50	14:00	Patrick Pradel / Allan Rennie	DfAM Network	DfAM
14:00	14:05	Mahdi Bodaghi	Nottingham Trent University, UK	Close



Ali Zolfagharian

Deakin University, Australia

Profile

Dr. Ali Zolfagharian is recognized for his innovative direction in 4D printing and has been acknowledged as a top 2% cited scientist by Stanford University and Elsevier for consecutive years. His accolades include the Alfred Deakin Medal for Best Doctoral Thesis and the Alfred Deakin Postdoctoral Fellowship. A co-founder of the 4D Printing Society and co-editor of the Smart Materials in Additive Manufacturing book series, Ali is a senior lecturer at Deakin University, Australia. His pioneering work spans 121 journal articles, 15 special issues, 8 book chapters, and 5 books in the realm of 3D printing of smart robotic materials.

Talk Title - Crafting Tomorrow's Robotics by 4D Printing

This presentation overviews a paradigm-shifting development in robotics, unveiling the potential of 4D printing. We explore how the intersection of additive manufacturing and smart stimuli-responsive materials converges to sculpt the future of soft robotics. We delve into the synergistic nature of design, modeling, and additive manufacturing, propelling the development of adaptable and sustainable robotic systems. Unveiling the potential for flexible production, customized designs, and wide-ranging applications across industries like automotive and healthcare steps into a realm where "The Pioneering Journey of 4D Printing of Robots" becomes the catalyst for reshaping tomorrow's technology landscape.



Frédéric Demoly

Belfort-Montbéliard University of Technology, France

Profile

Frédéric DEMOLY, is Professor at the University of Technology of Belfort-Montbéliard (UTBM, France) and also serves as the Director of the Department of Design, Optimization, and Modelling in Mechanics at ICB UMR 6303 CNRS. Holding an Engineering degree (UTBM, 2007) and a Ph.D. in Mechanical Engineering (UTBM, 2010), he conducted postdoctoral studies at EPFL, Lausanne. Joining UTBM as Assistant Professor in 2011, his research spans bio-inspired and AI-based design, multi-material additive manufacturing, and 4D printing. He's led funded research projects, currently heading a major 4D printing initiative in France. Recently, he was recognized as a laureate of an Innovation Chair at the Institut Universitaire de France.

Talk Title - Challenges in Designing for 4D printing

In the last few decades, the intersection of additive manufacturing (AM) and smart materials (SMs) has led to the emergence of a burgeoning field: 4D printing. This technology imparts an additional temporal dimension to 3D-printed objects through stimuli-responsive materials, enabling transformative capabilities in function, shape, and properties. Researchers from diverse fields have explored stimuli-SMs combinations using both commercial and custom 3D printers, showcasing remarkable proofs-of-concept. However, realizing practical applications and industry adoption requires overcoming interdisciplinary challenges. This talk provides a concise overview of 4D printing's progress, barriers, and prospects from a product-systems design perspective. It delves into fundamental SMs, processes, stimuli, and AM, surveying current research status and limitations. Moreover, it highlights opportunities, challenges, and outlines a research agenda for the next decade to foster intelligent product development for human and industrial benefits.



Dimitrios Lamprou

Queen's University Belfast, UK

Profile

Dimitrios Lamprou (Ph.D., MBA) is Professor (Chair) of Biofabrication and Advanced Manufacturing, Chair at UKICRS and the Chair of the APS Emerging Technologies Focus Group. Dimitrios, is the author of over 150 peer-reviewed publications, has over 350 conference abstracts, has given over 150 Invited Talks in institutions and conferences across the world, and has secure Funding more than £4M. PubMed-based algorithms (Aug 2023) placed him in the top 0.11% of scholars in the world writing about 3D Printing in the past 10-years. Dimitrios has also been named in the Stanford University's list 2021 & 2022 of World's Top 2% Scientists.

Talk Title - 3D and 4D Printing Applications in Pharmaceutics

New materials and manufacturing techniques are emerging with potential to address the challenges associated with the manufacture of pharmaceutical systems that will teach new tricks to old drugs. 3D & 4D printing is a technique that can be used for the manufacturing of dosage forms and medical implants, and offers a new paradigm for the direct manufacture of personalized dosage forms with the use of sustainable material and methods. Current approaches from our research Lab, towards the manufacturing of drug delivery systems and medical devices, will be covered and discussed.



Moataz Attallah

University of Birmingham, UK

Profile

Professor Moataz Attallah holds a chair in advanced materials processing at the School of Metallurgy and Materials University of Birmingham. His research focuses on additive manufacturing of metallic materials focusing on the process impact on the microstructure and structural integrity development. His research is conducted through research partnerships with various companies in the aerospace, defence, medical, space, and nuclear energy sectors. He co-authored over 200 journal and conference papers, 3 book chapters, and is a co-inventor on 5 patents.

Talk Title - Additive of Manufacturing of Mechanical Metamaterials using Shape Memory and Superelastic Alloys

The talk gives an overview on the use of additive manufacturing for the fabrication of super elastic and shape memory alloys, focusing primarily on the key challenges associated with their processing. This includes: the optimisation of build design, influence of powder quality, post-processing heat treatment, surface finishing, and the optimisation of mechanical performance.



Charlie C.L. Wang

University of Manchester, UK

Profile

Prof. Charlie C. L. Wang is currently Chair of Smart Manufacturing at the University of Manchester (UoM). Before joining UoM in 2020, he worked as a Professor at Delft University of Technology, The Netherlands and a Professor at the Chinese University of Hong Kong. Prof. Wang was the recipient of several awards, including the ASME CIE Excellence in Research Award (2016), the ASME CIE Young Engineer Award (2009), nine Best Paper Awards, five project-oriented technology innovation awards and three teaching awards. He was elected to be a Fellow of American Society of Mechanical Engineers (ASME) in 2013.

Talk Title - Optimization-Based Geometric Computing for Deformable Structures

Developing an efficient and reliable simulator for deformable structures which can handle the collision response well, is still a challenging task in the research of 3D/4D printing and soft robotics. In this talk, I will introduce our collision-aware simulator based on geometric optimization, which can efficiently handle realistic collision checking / response while incorporating a hyperelastic material property. Both actuated deformation and collision response for deformable structures are formulated as geometry-based objectives. The deformation results are obtained by minimizing the geometry-based objective function. The proposed pipeline performs a computational cost much lower than FEA-based physical simulation.



Dennis Douroumis

University of Greenwich, UK

Profile

Dr Dennis Douroumis is a professor in Pharmaceutical Technology and Process Engineering at the University of Greenwich, UK. His research activities focus on emerging technologies including: (a) 3D printing technologies for pharmaceutical dosage forms or novel medical devices (microneedles, bioresorbable scaffolds), (b) Continuous manufacturing processes for the development of medicinal products, and (c) Nanomaterial synthesis and surface modification for cancer treatment. Dennis has established several national and international collaborations with world-class colleagues/researchers including industrial funded projects and several EU/UK grants. He received the prestigious award of Eminent Fellowship of the Academy of Pharmaceutical Sciences for the excellence in the pharmaceutical sciences over a prolonged period with an emphasis on advocacy and leadership. He has also received a prestigious award for his “Outstanding Scientific Contribution” in Pharmaceutical Processes and invited to deliver the Award Lecture, sponsored by AstraZeneca.

Talk Title - 3D Printing for Pharmaceutical and Medical Applications

3D printing technologies have been employed for the design of novel pharmaceutical and medical products. This presentation highlights how 3D printing enables the design and fabrication of paediatric dosage forms at the point of care. Furthermore, more advanced printing approaches can be used for the manufacturing of medical devices such as transdermal microneedle arrays or biodegradable and biocompatible drug eluting stents for coronary artery diseased.

About the DfAM Network:

The purpose of the EPSRC design for AM network is to connect the wider UK design for AM academic research community alongside those in industry that are experienced practitioners of additive manufacturing technologies, such that we can benefit from sharing knowledge, developing research themes and working collaboratively to ensure that design for AM is given the best platform possible.

By bringing together the design for AM community, the network aims to reach out to the widest possible audience that might benefit from design for AM research; identify future research directions and facilitate larger and more adventurous research collaborations.



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<https://www.designforam.ac.uk/>