Plan Overview

A Data Management Plan created using DMPonline

Title: Beyond Nature: Luffa-Inspired Hierarchical Structural Materials through AI-Driven Design and Additive Manufacturing (BLISS)

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Funder: Engineering and Physical Sciences Research Council (EPSRC)

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Project abstract:

BLISS aims to unlock new opportunities in high-performance structural materials by translating the hierarchical fibrous geometry of *Luffa cylindrica* (sponge gourd) into innovative engineered material and structural systems. Despite being composed of relatively weak, low-stiffness organic fibres, Luffa exhibits remarkable mechanical efficiency, including high specific stiffness, strength and energy absorption. Its performance arises primarily from its complex, interconnected, hierarchical architecture. *BLISS* seeks to exploit these geometric principles using the wider range of engineering materials available today, creating lightweight, resilient and multifunctional structural technologies that go beyond the capabilities of conventional solutions.

The project will address three fundamental challenges: (1) developing appropriate 3D imaging approaches to capture Luffa's complex hierarchical geometry; (2) identifying and characterising its underlying geometric patterns and structural principles; and (3) demonstrating the potential to reproduce and adapt these architectures using different engineering materials. By integrating advanced 3D imaging, AI-driven geometric analysis and design, and additive manufacturing, *BLISS* will establish a pathway for translating natural architectures into engineered structural elements. These will incorporate diverse material systems, including metals, fibre-reinforced polymers and functionalised nanocomposites.

BLISS moves beyond conventional biomimicry, which often focuses on replicating natural materials, towards understanding and exploiting the fundamental geometric principles underlying their performance. Recent advances in imaging, artificial intelligence and additive manufacturing provide unprecedented opportunities to characterise, optimise and reproduce complex natural architectures. The project will establish new fundamental understanding of hierarchical structural materials and demonstrate how these principles can be adapted to discover previously unexplored material and structural technologies.

Lightweight, resilient and resource-efficient structural technologies are essential for achieving the UK's net-zero ambitions and strengthening industrial competitiveness. *BLISS* will contribute to these priorities, particularly in offshore renewable energy and construction, by enabling structures with improved mechanical performance, reduced material consumption and lower embodied energy. Its potential applications also extend to aerospace, automotive, biomedical and defence sectors. Furthermore, integrating multifunctional capabilities, such as electromagnetic interference shielding, alongside structural performance could reduce material requirements and reliance on critical minerals.

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Beyond Nature: Luffa-Inspired Hierarchical Structural Materials through AI-Driven Design and Additive Manufacturing (BLISS)

Data Collection

What data will you collect or create?

This project will involve both qualitative (e.g. images) and quantitive (numerical results, experimental results) data. Project will create primary data through experiments, 3D scanning and numerical modelling. Project will also collect secondary data baout Luffa geometries from published litreature.

How will the data be collected or created?

Secondary data will be collected from the published scientific litreature.
Generation of the 3D scanning images will be conducted according to the existing best practices for microCT imaging. Experiments will be carried out according to the relevant well-established experimental testing standards.

Documentation and Metadata

What documentation and metadata will accompany the data?

Data will be accompanied by standard README text files and domain-specific metadata to ensure others can interpret the files.
Data will be managed to be **F**indable, **A**ccessible, **I**nteroperable, and **R**eusable (FAIR).

Ethics and Legal Compliance

How will you manage any ethical issues?

Question not answered.

How will you manage copyright and Intellectual Property Rights (IPR) issues?

Dissemination and intellectual property(IP) strategies will reflect the maturity and commercial potential of each outcome. Fundamental research outcomes will, where appropriate, be published open-access and shared through open-source platforms to encourage collaboration and accelerate innovation. Patents will be pursued for commercially valuable technologies and products, where justified.
Edinburgh Innovations (EI), the University’s commercialisation service, will support technology assessment, IP protection and exploitation.

Storage and Backup

How will the data be stored and backed up during the research?

Data will be stored on University of Edinburgh's research DataStrore.
DataStore provides enterprise-class storage with guaranteed backup and resilience. Data is retained on DataStore until deletion by the data owner. The backups provide resilience in the case of accidental deletion and against incidents affecting the main DataStore storage. The data are automatically replicated to an off-site disaster recovery facility, with 10 days of file history visible online. Off-site tape backups keep 60 days of history of the filesystem. The 60 day rolling snapshots allow important data to be recovered to a

prior state, by request if beyond the visible period.
Sensitive data stored on DataStore will be further protected by the use of 256 bit encryption as required by University policy

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Selection and Preservation

Which data are of long-term value and should be retained, shared, and/or preserved?

Data such as images and experimental results created during the project will have long-term value, thus should be retained and preserved.

What is the long-term preservation plan for the dataset?

Data will be made as open as possible and as closed as necessary, releasing primary data to the public with minimal restrictions.
all data will be deposited in DataShare- Edinburgh University's open access data repository, and shared.
Raw and published data will be retained for a minimum of 10 years post-project

Data Sharing

How will you share the data?

University of Edinburgh Sharepoint will be used to share data during the project.
After the project, all data will be deposited in DataShare- Edinburgh University's open access data repository, and shared.
Published datasets will typically be shared within 3 to 6 months of project completion.

Are any restrictions on data sharing required?

Question not answered.

Responsibilities and Resources

Who will be responsible for data management?

Principal Investigator: Overall accountability for data collection, ethical compliance, and timely deposit
IT Support: Technical implementation of storage, backups, and metadata tagging

What resources will you require to deliver your plan?

IT support will be required (10% FTE)