# Engineering and Informatics

**Project: 2026ENGINF01**

**Additive manufacturing of stimuli responsive scaffolds for biomedical applications**

**Supervisor: Elizabeth Rendon-Morales**

Biomaterial based scaffolds have emerged as a potential intervention for personalized drug delivery, wound healing and skin tissue regeneration. These are intricate three-dimensional structures, serving as carriers for cells and medications, facilitating their integration and delivery into the body.

This research project in collaboration with Queen Victoria Hospital is about improving the design and fabrication of 3D printed scaffolds for applications in drug delivery and regenerative medicine. We will investigate the use of additive manufacturing (AM) technologies combined with advanced materials that have the ability to change their shape, properties and functions over time in response to external stimuli such as magnetic fields and light sources. It also explores the adoption of novel robotic based volumetric imaging and its integration with AI tools for the development of personalised 3D printed scaffolds models for tissue regeneration.

**Project: 2026ENGINF02**

**Design and development of high precision robotic interfaces and AI-based navigation for biomedical applications.**

**Supervisor: Rodrigo Aviles-Espinosa**

This project is about improving human-assisted high precision biomedical tasks aiming to achieve an increasingly automated approach. It will investigate novel approaches and methodologies for improving robot motion using AI based-navigation. The project will investigate the pathways to enhance autonomy in our high precision robotic systems by adopting image-based visual servoing (IBVS), position-based visual servoing (PBVS), and hybrid approaches.

This is to be achieved by combining novel AI and machine learning techniques for image quantification and analysis including deep learning algorithms to automatically segment, register, to enable both autonomous navigation and high-speed quantitative diagnostics.

**Project: 2026ENGINF03**

**Scene and movement alignment toward human motion generation**

**Supervisor: Temitayo Olugbade**

Scene-aware generation of synthetic human data requires aligned scene and human movement data whereas a large number of existing human movement datasets are without corresponding scene data. This project will investigate alignment of related 3D scenes and human movement data from separate datasets. The project will use existing scene and human movement datasets. It will specifically compare a machine learning approach with a constraint-based method.

Sui et al. (2026). A survey on human interaction motion generation. International Journal of Computer Vision, 134(3), 113.

Wang et al. (2022). Humanise: Language-conditioned human motion generation in 3d scenes. Advances in Neural Information Processing Systems, 35, 14959-14971.

Olugbade et al. (2022). Human movement datasets: An interdisciplinary scoping review. ACM Computing Surveys, 55(6), 1-29.

Olugbade et al. (2024). The EmoPain@Home dataset: Capturing pain level and activity recognition for people with chronic pain in their homes. IEEE Transactions on Affective Computing.

Dai et al. (2017). ScanNet: Richly-annotated 3D Reconstructions of Indoor Scenes. Proc. Computer Vision and Pattern Recognition (CVPR).

**Project: 2026ENGINF04**

**Cardiac electrogram classification using deep learning methods**

**Supervisor: Luc Berthouze**

This project focuses on the automated classification of atrial fibrillation (AF) electrograms. The dataset consists of endocardial and epicardial electrograms recorded under controlled pacing protocols from two patient groups:

(i) patients with clinically diagnosed AF, including paroxysmal, persistent, and long-standing persistent forms; and

(ii) patients without AF who undergo invasive cardiac mapping for other cardiac conditions.

All recordings are obtained during pacing to ensure clean, repeatable, and comparable electrogram data across patients and conditions. By working exclusively with paced AF electrograms, the project targets differences linked to underlying atrial substrate and AF phenotype rather than variability arising from spontaneous rhythm dynamics. The work is embedded within an ongoing collaboration with University Hospital Sussex NHS Foundation Trust (UHSx) and contributes to a broader programme developing data-driven methods for analysing atrial electrophysiology in clinically realistic settings.

**Project: 2026ENGINF05**

**Can Neural Networks Recover Meaning from Encrypted Text? Exploring the Geometry of Encryption in Embedding Spaces**

**Supervisor: Olayinka Ajayi**

This project explores a fundamental question at the intersection of machine learning and cryptography: Can a neural network recover the semantic meaning of encrypted text without explicitly performing classical decryption? In classical cryptography, plaintext is transformed into unintelligible ciphertext, and decryption restores the original text exactly. In contrast, modern deep learning models are capable of extracting semantic structure from noisy or corrupted inputs. This project investigates whether semantic information survives encryption in a form that is detectable in high-dimensional embedding spaces

**Project: 2026ENGINF06**

**Title: AI-Assisted Optical Diffractive Models for Real-time Image Processing**

**Supervisor: Mohammad Neshat**

This project investigates AI-assisted optical diffractive models for real-time image processing using simplified computational simulations. The aim is to explore how optical-inspired systems—specifically diffractive layers—can process visual information at the speed of light, offering a potential alternative to conventional digital computing.

Such approaches are highly relevant to emerging applications where **ultra-fast and energy-efficient processing** is critical. Examples include real-time object recognition in autonomous vehicles, high-speed quality inspection in manufacturing, biomedical imaging for rapid disease detection, and next-generation augmented/virtual reality systems requiring low-latency vision processing. Optical diffractive computing also has potential in security and sensing, enabling instant pattern recognition without heavy digital hardware.

In this project, the student will develop a 2D numerical model where images are treated as optical fields that propagate through a small number of virtual diffractive layers. These layers, represented by trainable masks, will be optimized using basic machine learning techniques to perform a simple task such as digit or pattern classification. The model will be evaluated under ideal and noisy conditions and compared with a standard digital approach.

**Project: 2026ENGINF07**

**Title: Opportunities and Challenges of Automating Topic Analysis using LLMs**

**Supervisor: Maria Teresa Llano**

Topic analysis is a qualitative research method widely used in the research community; however, it requires a lot of resources, such as time and people. Current AI technologies, such as cloud-based LLMs, have been used to automate parts of the process of topic analysis in different domains. The idea of this project is to develop a proof of concept system that automates stages of topic analysis using local LLMs instead of cloud-based LLMs. An existing survey paper will serve as the baseline for comparison of performance between a manual and an automatic approach through the system.

**Project: 2026ENGINF08**
**Electricity from underground: UK geothermal power**

**Supervisor: Martin White**

It is an exciting time for geothermal power in the UK. At the beginning of March 2026, the first geothermal power plant in the UK was switched on. The plant will use heat extracted from deep underground to generate electricity for over 10,000 homes. Geothermal power is an excellent addition to our national energy mix, providing clean, base-load energy that is available 24-hours, and 365-days a year. Geothermal power could meet a fifth of global electricity needs, but amongst challenges related to long development timelines, and challenging policy and regulatory frameworks, high costs remain a key roadblock.

This project will carry out the techno-economic optimisation of an innovative concept for surface-level geothermal power plants that could improve power output by up to 30%, thereby enabling a step change in the revenue from a given geothermal reservoir over its lifespan to help overcome financial barriers. The concept is based on the idea of wet-to-dry expansion, where molecularly complex fluids are exploited inside the power plant to enable the efficient expansion of liquid-vapour mixtures to fully vapour conditions using a turbine. The aim of this project will be to develop a techno-economic model of the power plant that can assess both the thermodynamic performance of the plant, as well as the capital cost of key components such as the heat exchangers, pump and turbine. This model will be coupled to a suitable optimisation routine to identify optimal system designs for different geothermal applications, and these designs will be benchmarked against conventional geothermal power plants to assess the potential benefit.

**Project: 2026ENGINF09**

**Supervisor: Martin Berger**

I support various projects in this space. I am open-minded regarding the exact details of the project. Please contact me (M.F.Berger@sussex.ac.uk) for questions and to discuss ideas, below are examples of projects I would be interested to support.

**Implementing automatic theorem proving on GPUs -** GPUs are the work-horses of high-performance programming. The acceleration they provide to applications compatible with their programming paradigm can surpass CPU performance by several orders of magnitude, as notably evidenced by the advancements in deep learning. A significant spectrum of applications, especially within automated reasoning like SAT/SMT solvers and model checkers has yet to reap the benefits of GPU acceleration.One conjecture why is that the algorithms used in logic based verification are intrinsically sequential and cannot be parallelised. I conjecture that that is false. An interesting project space would be to experiment with the implementation of the corner stone of all logic, namely decision procedures. It would be fun to implement at least one such decision procedures on a GPU and see how fast they can be made.

**ARC challenge -** The ARC challenge (short for: Abstraction and Reasoning Challenge) is one of the most important AI benchmarks. It was designed specifically to be difficult for deep-learning. It is intended to measure how close we are to AGI. They mostly use either program synthesis or LLMs, but mostly combine both. I think developing interesting ideas to do with program synthesis and program search (with or without LLMs) is especially fun.

**Computer security at the hardware / software boundary -** More and more security vulnerabilities, happen at the hardware / software boundary, examples include Spectre, Meltdown, and Rowhammer.

**Formalising mathematics or theoretic computer science in Lean (or similar) -** Interactive theorem provers like Lean (https://en.wikipedia.org/wiki/Lean_(proof_assistant)) have recently become popular, both in: deep learning for RLVR (reinforcement learning with verified reward), smashing various mathematics related benchmarks (e.g. the IMO Grand Challenge). But also for building formally verified bases for Mathematics, High energy physics and Computer science. I'm especially interested in the mathematics and computer science of Monte Carlo simulation, as often used in high-energy physics.

**Just-in-Time (JIT) compilation with PyPy -** Designing programming languages is great fun. Writing an interpreter for a language is easy, but does not deliver speed. Making a new language fast is difficult because performant compilers are expensive to engineer.

The problem is especially significant for dynamically typed languages like Python or Javascript, that are intrinsically slow. JIT compilers (short for just-in-time) make their performance (somewhat) bearable, but at the cost of even more complex compilers.
Meta-tracing JITs convert a language interpreter into a JIT compiler, thus removing much of the cost of writing JITs by hand, see my compiler notes for a superficial overview. The PyPy framework is a widely used meta-tracing framework.
**Programming language design (and implementation) -** Designing programming languages is great fun. Only our imagination is the limit. Designing a dream language is also a great way of becoming a better programmer. With agentic-coding much of the grind-work can now be automated away.
I think developing interesting ideas to do with typing systems and/or meta-programming is especially fun.
**RISC-V -** RISC-V is an open-source instruction-set architecture (ISA) designed to be modular. This open nature facilitates academic research and industrial adoption. Projects include: Writing a RISC-V simulator, Implementing a RISC-V using Verilog, or similar languages, Designing a new RISC-V extension.
**Semirings and systolic arrays: systolic arrays for Semiring -** Semirings are one of the most general and widely used mathematical structures. They generalise rings, by weakening the requirement that addition is an abelian group. In a semiring, addition needs only be a commutative monoid. Matrix multiplication can be defined for general semiring.
In recent years TPUs and tensor cores came to the for as hardware accelerators for deep learning. They are typically all based on systolic arrays a simple processor architecture that is especially good for matrix operation like matrix multiplication. To date all those TPUs and tensor cores hard-code floating point numbers (which makes sense for neural networks). I think it would be fun, to generalise this a tiny bit and build a systolic arrays for general semirings.
**AI-agents as research helpers -** The last few months have seen an explosion in the ability of LLMs to aid science. This is typically driven by some feedback loops, including RLVR (reinforcement learning with verified rewards) in training. Often this is combined with feedback loops involving users (e.g. Agent-Driven Development in programming). Sometimes it is also combined with other search techniques.
**Pydrofoil (or QEMU) for processor simulation -** Before processors are "taped out" meaning: printed to silicon, they undergo extensive design and verification stages. But since, in those stages, they don't exist as physical processor, they are designed and verified using simulation. One well-known such simulator is QEMU that is widely used in industry. I have been involved with Pydrofoil based on PyPy.