COMPUTING RESEARCH

School of Engineering, Computing and Mathematics
Research in the School of Engineering, Computing and Mathematics brings together expertise from a broad spectrum of disciplines. The school has an excellent reputation for research and knowledge transfer. We have a number of active computing research groups with internationally recognised researchers in all its disciplines.

The school is based on its own dedicated campus at Wheatley, five-miles outside of Oxford City with industry-leading facilities, laboratories and equipment.

Research is structured into two large research centres:

- **Dependable Systems Engineering**
- **Intelligent Systems Engineering**

Students are attached to these research groups and work alongside experienced researchers as well as with collaborators from across the industry and other academic institutions.

For further information on Computing research, the Centres or the individual research groups please see the staff contact details in each research group section.
DEPENDABLE SYSTEMS ENGINEERING CENTRE

The research groups in this centre are focused on the reliability and integrity of software from a programming and software engineering perspective. Work includes formal methods for programming, the design of cloud and web-based systems and applications in data mining, cyber security, e-health and advanced circuit design.

Research Groups
- Formal Methods
- Software Engineering
- Cyber Security
- e-Health and PEPPER
- Statistics and Data Analysis
- Reliable circuits and memristors
- Cloud and Network Softwarization
- Web-based Systems and Services

INTELLIGENT SYSTEMS RESEARCH CENTRE

The research groups in this centre address the application of computing to a range of intelligent computer systems. There are groups on robotics, computer vision and augmented reality as well as transport and medical systems.

Research Groups
- Robotics
- Machine Learning and Computer Vision
- Uncertainty in Artificial Intelligence
- Performance Augmentation Lab
- Electronics and Communications
THE APPLICATION PROCESS

The process is broken down into 5 steps:

1. Check essential requirements
Before you apply, please check you meet entry requirements as well as the financial requirements of the programme.

2. Explore our research groups and supervisory staff pages
Explore the research groups and their associated staff member to see how your chosen field of study aligns with the research portfolio within the school.

3. Agree your research
Contact postgraduate research tutor Dr Tjeerd Olde Scheper to discuss your proposed research. You’re welcome to contact academics to help you develop your ideas.

4. Formulate your proposal
When you have agreed you research project with Tjeerd, he will ask you to prepare and submit a proposal. If the proposal is acceptable Tjeerd will ask you to make a formal application, or give you advice on how the proposal may be improved.

5. Gather required documents and submit:
When you are ready, submit your UCAS Postgraduate application along with the required supporting documents through the UCAS Postgraduate website. You should note that we cannot consider your application for admission until all the documents noted above have been received, including financial documentation.

CONTACT US

For enquiries about research projects in these groups please, contact the postgraduate tutor Dr Tjeerd Olde Scheper (tvolde-scheper@brookes.ac.uk).

WHAT RESEARCH WE CAN SUPERVISE

We welcome research proposals related to any of the subjects covered by the research groups represented by our two research centres. The following pages provide some suggested project titles as a guidance to the type of computing research that can be supervised in the school.
SUPERVISORS AND PhD PROJECT TITLES

Within the School there is a wide range of knowledge and expertise. We are fortunate to have leading academics in their field who also supervise PhD projects. The topics listed below are broad and can be specialised to the individual.

DEPENDABLE SYSTEMS ENGINEERING CENTRE

- Dr Arantza Aldea
  - Analysing medical data to identify patient profiles and use techniques such as data mining and machine learning to customise treatment (possible case studies: obesity, diabetes)
  - Use smart devices, sensors and AI to develop a personalised nutrition recommendation system.

- Dr Kashi Basu
  - QoS management in Tactile Internet based cyber physical systems using machine learning/ queuing theory
  - Software defined network traffic engineering for emerging applications.

- Dr Ian Bayley
  - Formalisation of and reasoning about security patterns
  - The use of abstract models of dynamic memory management to reason about memory safety.

- Professor Rachel Harrison
  - Multi-Criteria Decision Support using AI
  - Automated Review Classification and Analysis.

- Dr Abusaleh Jabir
  - Modelling, Designing, and Testing of Self Reparable Systems Based on Memristive Devices
  - Applications of Memristive Devices e.g. for Artificial Neural Networks, Neuromorphic Systems, In Memory Processing, Secure and Uncloneable Hardware.

- Dr Samia Kamal
  - The role of an innovative mindset in developmental opportunities for STEM disciplines
  - Pedagogical issues relating to computer science education in higher education.

- Dr Clare Martin
  - Modelling of angelic and demonic nondeterminism with multirelations
  - Formal modelling of diabetes self-management tools and techniques.

- Dr Muhammad Younas
  - Big data management in the cloud
  - Web information searching and extraction.

- Professor Hong Zhu
  - Testing AI Software Applications and Intelligent Systems (it could be specialised to a more focused topic, such as test adequacy problem or test oracle problem of testing, etc.)
  - AI Applications in Automated Software Engineering for the Cloud Computing applied to applications such as fault localisation, service composition, microservice ecosystem evolution or load balancing.

INTELLIGENT SYSTEMS RESEARCH CENTRE

- Dr Peter Ball
  - Non co-operative multi-user heterogeneous wireless communication in an intelligent transport system environment
  - Low energy and low complexity security solutions for autonomous vehicles.

- Professor Nigel Crook
  - Autonomous moral machines: Developing robots with moral competence
  - Developing Artificial Intelligence technologies that will support high quality forensic evidence gathering during police interviews with children.

- Professor Fabio Cuzzolin
  - Deep learning for event detection and prediction
  - Designing machines that can read your mind.

- Dr Tjeerd Olde Scheper
  - Machine Learning using Critical Systems - Exploring the capabilities of dynamic systems for nonlinear representation space generation
  - Application of Critical Analysis on experimental data - Using Critical Analysis to identify similarity properties in data.

- Dr Shumao Ou
  - IoT and Machine Learning to Improve Sports Analytics
  - Deep Representation Learning for Racquet Player Motion Prediction.

- Dr Matthias Rolf
  - From (deep) reinforcement learning to symbolic planning by learning goal representations
  - Social human-robot interaction based simulated need systems.

- Dr Fridolin Wild
  - Using wearable sensors and Augmented Reality for self-care physiotherapy
  - Guided quality assurance and predictive maintenance applying Augmented Reality in the automotive sector
  - 3D Cortana/Alexa/Siri: Implementation and evaluation of technology acceptance of a holographic AI.
Mireya Munoz Balbontin
Research title: Criticality control of insulin-release
Supervisor: Dr Tjeerd Olde Scheper

Research Project:
The aim of this project is to get a better understanding of mechanisms involved in insulin release to allow better management of the condition. In order to achieve it, we are developing a bottom-up approach to represent the system, using a modelling methodology that will focus on maintaining the dynamic components of the system. This research is centred around the development of a biologically inspired phenomenological model of insulin release.

The insulin release system is one of high complexity, given all the parameters and conditions that have to be met in order to achieve stability. Mathematically, this translates to a highly non-linear dynamical system. After studying the state of the art, it was found that the tendency in the mathematical modelling of the system is to reduce its complexity. This finding assisted in the design of a bottom-up methodology focused on maintaining the complex mathematical properties of the system, where non-linear local dynamic states contribute to a globally stable glucose function. This approach is supported by the discovery of oscillations in the glucose-insulin release system in the pancreas. A system such as this one is modelled using oscillators that exhibit criticality, a property of rate controlled chaotic systems which allow the desired dynamics. Three different models are being employed for comparison of their dynamic capabilities and biological relevance, and will be used as a base for the development of the model.

Will Guest
Research title: Augmented Dexterity: Advancing action recognition using machine-learning tools to capture expert knowledge within Augmented Reality
Supervisors: Dr Fridolin Wild and Dr Tjeerd Olde-Scheper

Research Project:
My PhD research is all about our hands. We learn, teach, communicate and construct our world with these highly evolved tools. With these we have designed and built systems that assist us to do ever more complicated and subtle tasks. One class of such systems, Augmented Reality devices, and in particular head-mounted digital displays, means we now can overlay the real with the virtual in a believable and immersive way.

Armed with these technologies, there is a pressing and largely unexplored need to understand how to use our hands effectively in this new space. In order to successfully interpret and use our primary appendages, there is much work to be done in both action recognition and human-computer interaction.

In addressing this need, my undertaking is to develop a training system for procedural guidance in the workplace. It looks at both of these parts, as they must be used together to be effective. The action recognition is built on movement and electromyographic data and the computer in question is the Microsoft HoloLens, alongside a number of other, simpler, wearable devices.

I will use an Augmented Reality (AR) prototype (being developed in the WEKIT European project) to collect data which are experts’ recordings of their hands, in the fields of aircraft maintenance, medical diagnostic imaging and astronaut training. This data is re-playable to trainees to assist them in completing a task and will also be used to train an intelligent algorithm to classify actions.
**RESEARCH PROFILES**

**Xiaohan Yang**  
Research title: *PhD research in Design Analysis and Tests of Reliable Memristor Based Logic Architectures*  
Supervisor: Dr Abusaleh M. Jabir

**Research Project:**  
Conventional Metal Oxide Semiconductor (MOS) transistor is reaching its minimal limit. To keep increasing transistor density and maintaining Moore’s law, scientists have been exploring alternative technologies for the evolution of computing devices. A memristor, a two-terminal nano-scale electronic device, is a highly promising technology. So far, memristors have been applied in areas such as high density memory design, neuromorphic system, secure and cryptographic system and logic design etc.

My research work is based mainly on memristive logic architecture design. We proposed a novel hybrid high-performance single-cycle memristive multifunction logic architecture and design a highly compact full adder logic circuit and memristive bit parallel multiplier. Both of these memristive systems show considerably smaller area cost and lower power requirement compared to the pure CMOS implementation. Currently, I am working on physical unclonability in memristive hybrid systems.

The research I have done so far leads me to believe that memristive systems will potentially expand to our everyday computing and mobile devices.

**Alla Vovk**  
Research title: *Multi-sensory model of spatial user interaction in augmented reality*  
Supervisor: Dr Fridolin Wild and Professor Nigel Crook

**Research Project:**  
The aim of this research is to reconfigure spatial interaction with physical world for empowering human learning and training using augmented reality (AR). AR is the synthesis of real world and virtual imagery. It is the result of the introduction of computer generated objects into the field of human perception to supplement information about the surrounding environment.

My research seeks to understand the extent of impact on human performance and how different types of spatial user interface design may influence its effectiveness. The idea is to create a comprehensible representation of knowledge and its systematisation in knowledge-intensive environments which enables intuitive interactions with holographic objects. The work about knowledge environments in augmented reality does not follow established patterns or design rules – each approach defines its own method on how to convey information. The proposed work aims towards defining design guidelines for AR data representation in the area of spatial computing.

**Suman Saha**  
Research title: *Spatio-temporal human action detection and instance segmentation in videos*  
Supervisor: Professor Fabio Cuzzolin

**Research Project:**  
With the exponential growth in digital video content, automatic video understanding is now at the forefront of computer vision research. This project is developing models for automatic human action detection in videos and also addresses the space-time action instance segmentation problem. Both action detection and instance segmentation play vital roles in video understanding.

A novel human action detection approach based on a frame-level deep feature representation combined with a two-pass dynamic programming approach has been developed. The method obtains a frame-level action representation by leveraging recent advances in deep learning based action recognition and object detection methods.

We are working on a novel deep network architecture which learns a video-level action representation by classifying and regressing 3D region proposals spanning two successive video frames. The proposed model is end-to-end trainable and can be jointly optimised for both proposal generation and action detection objectives in a single training step.

We are also addressing the problem of action instance segmentation in which multiple concurrent actions of the same class may be segmented out of an image sequence.

We demonstrate the performance of our proposed models on challenging action detection benchmarks achieving new state-of-the-art results across the board and significantly increasing detection speed at test time.
Formal Methods

Research in applied formal methods addresses fundamental problems in software engineering practice. Mathematical theories are employed to develop novel and intelligent solutions with a solid foundation in software engineering methodologies and techniques.

The most notable work carried out in the research group recently includes:
- Formal definitions of the semantics of software modelling languages
- Rigorous specification of software design knowledge, such as design patterns, and automatic validation and verification of their correct applications
- Automation of software testing based on formal specifications
- Service oriented programming languages, tools and methods for developing cloud-native software, etc.

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Dr Ian Bayley
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Outline research topics:
- Programming languages and integrated DevOps environment for microservices
- Formal methods for software design
- Algebraic specification and automated testing of cloud software

For further information on formal methods research:
www.brookes.ac.uk/ecm/research/computing/applied-formal-methods/
Software Engineering

Research in empirical software engineering helps us to understand, predict, control, manage, characterise and improve software. Automated software engineering exploits mathematical theories to develop optimal software solutions. Improving the quality of software (its usability, reliability, performance, and supportability) helps to ensure that the world is a safer and more habitable place.

This work improves software engineering by using artificial intelligence tools and techniques. For example, it facilitates fault finding by using algorithms to automatically locate faults, thereby assisting the debugging process that is a large part of software development.
Cyber Security

The research focuses on intelligent cyber security systems, network security and secure software engineering. A current research involves a study into secure and anonymous exchange of incident response data based on previous work on digital evidence ‘bags’.

The aim of the work is to provide a way for organisations to securely share security incident data so that the sharing will not damage the organisation but can also be relied upon by other organisations as valid.

Other research work is in the area of cyber security pedagogy and applying AI and ML techniques to system defence. There is also work on development of attack patterns and the development of techniques for secure software engineering.
e-health
Research involves multiple aspects of eHealth including artificial intelligence, usability and data visualisation. There is particular interest in mobile technology for type 1 diabetes, but work has also been conducted on mobile applications for other branches of health including: dementia, brain injury, infectious disease, lung cancer, Parkinson’s disease and Huntington’s disease.

PEPPER Project
Oxford Brookes has been awarded a major European project which is part of the EU Horizon 2020 programme called ‘Patient Empowerment through Predictive PErsonalised decision support’ (PEPPER). The project partners are Imperial College London, University de Girona, Girona Biomedical Research Institute, Romsoft SRL and Cellnovo Ltd.

People with Type 1 diabetes traditionally manage their condition by drawing blood from their fingertips several times a day to test their blood sugar levels in order to calculate a dose of insulin to inject.

A growing number of people now administer their insulin via a wearable pump and may also wear continuous glucose monitors. The aim of this research is to combine wearable technologies and artificial intelligence to create a personalised decision support system for diabetes management that will give people freedom from daily decision making. The project is also examining the extent to which human behavioural factors and usability issues have previously hindered the wider adoption of such personal guidance systems.

For further information on e-Health research:
www.brookes.ac.uk/ecm/research/computing/

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Statistics and Data Analysis

This group focusses on advanced statistical modelling, including, multi-level modelling, non-linear models, linear and generalised linear mixed models. There is also expertise in analysis and modelling of time series data, both in time and frequency domain.

This research has been applied to modelling and analysis for Multiple Sclerosis, Parkinson’s disease, dementia, strokes and physical rehabilitation.

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For further information on statistics and data analysis research:
www.brookes.ac.uk/ecm/research/computing/
Reliable Circuits and Memristors

The Advanced Reliable Computer Systems (ARCoS) group carries out leading research in the design, tests, and verification of reliable and secure computer and sensor systems with special emphasis on devices and systems built with the emerging memristor nanotechnology.

The focus of this group is:

- Error and attack tolerant electronic systems designs, especially against soft error based attacks
- Modelling, design, and testing of self-reparable memristive devices
- Novel and robust memristor based nano systems and sensor technology
- Secure and physical uncloneable electronic hardware
- Automatic design of electronic hardware

Outline research topics:

- Memristor nanotechnology based design, tests
- Verification of reliable and secure electronic systems

For further information on Reliable circuits and memristors research:
www.brookes.ac.uk/ecm/research/computing/
Cloud and Network Softwarization (CloudNets)

Cloud provides a large scale computer and data storage infrastructure which is used on an on-demand basis in a distributed and flexible manner enabling companies and individuals to consume computer resources as utility services in contrast to traditional approach of building and maintaining proprietary infrastructure.

Alongside cloud, networking is also undergoing a major overhaul with the softwarization and virtualisation of networking components. This has accelerated innovation and research in network design, maintenance and management with the provision of predictable level of service based on the application’s requirements.

Cloud and Network Softwarization are two significant disruptive technologies that can combine to provide a distributed virtual pool of computer, storage and networking infrastructure to support wide range of existing and emerging applications. In this context, our research in the field focuses on the following domains:

- Big Data and NoSQL databases
- Cloud and web-of-things
- Network performance modelling and analytics
- Smart grid communication
- Vehicle-to-everything (V2X) networks

Outline research topics:
- NoSQL and big data management
- Cloud computing - transactions management, service selection, cloud federation
- A cloud based distributed software-defined networks (SDN) controller architecture
- Virtualised communication framework for smart grid
- References for the earlier submission on virtualised smart grid

Web-based Systems and Services

The web has brought a new revolution in the information age and is used by billions of people in various domains ranging from simple web browsing through to social media to large scale commercial and e-business applications.

This research focuses on the emerging and novel concepts, architectures and methodologies for modelling, designing and developing web-based systems and services.

The main focus of this research is on the following topics:
- Service-oriented computing and web services
- Web information searching and extraction
- Web and database systems
- QoS of web-based systems and services
- Testing of web-based system and services
- Scaling and elasticity of web services

The research work has applications in different areas such as online E-Business services, transaction processing systems, and web searching applications among others.

Architecture of Web of Smart Grid Things

For further information on computing research: www.brookes.ac.uk/ecm/research/computing/
Or see more about cloud net research: www.tech.brookes.ac.uk/CloudNets/index.php
Cognitive Robotics

The cognitive robotics group aims to develop and integrate methods of artificial intelligence and machine learning as well as aspects of design and mechanical engineering into robotics systems. One particular area of interest is human-robot interaction: how can robots be designed and programmed to interact and collaborate with humans? How can robots pick up possible emotional signals from a human, and react appropriately?

New robots are created in the group to facilitate this fluent human-robot interaction. The new humanoid robot BLU, 3D-printed in our new fab-lab, aims at conversational interaction with humans. The bio-inspired robotic head and neck Eddie explored an entirely novel bionic actuation design to facilitate interactions by means of head gestures.

Several projects aim at developing ethically sensitive robots, which is increasingly important as robots become more capable and autonomous. We are investigating how robots may be manually programmed to behave ethically, but also possible limitations of such manual approaches which might be overcome by employing techniques of machine learning.

Outline research topics:
- Human robot interaction
- Machine learning for robotics
- Developmental robotics
- Robot ethics

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For further information on Cognitive Robotics research:
www.brookes.ac.uk/ecm/research/computing/cognitive-robotics/
Machine Learning and Computer Vision

Machine learning is the branch of artificial intelligence which aims at creating machines that can learn from data. Within computer vision, machine learning is key to designing algorithms capable of intelligent reasoning with images and videos, e.g., recognising people and events, reconstructing unknown environments and capturing motion.

From its inception in 2012, Professor Fabio Cuzzolin’s Artificial Intelligence and Vision research group has established a leading position in the field of machine learning for computer vision, in the company of groups in Stanford, INRIA and Oxford University, with a strong focus on video understanding. In particular a deep learning approach to action detection and recognition from videos has been developed which has surpassed all other competitors in terms of accuracy, while demonstrating better than real time capabilities.

Dr Tjeerd Olde Scheper is carrying out research into bio-inspired learning and control which is resulting in novel applications in the area of engineering, health and machine learning. The methods allow improved performance of control systems, exploitation of unstable control domains, and increased yields.

Outline research topics:
- Emergent critical systems (rate control of chaos)
- Swarm robotics to enhance parse world observations

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For further information on Machine Learning and Computer Vision research:
www.brookes.ac.uk/ecm/research/computing/artificial-intelligence-and-vision/
Uncertainty in Artificial Intelligence

Uncertainty is widespread in all areas of human endeavour, from business to science. Probability measures, the simplest mathematical model of uncertainty, have been recognised as incapable of modelling ‘second-order’ uncertainty, i.e., lack of information on the probability law itself governing the process. Examples of problems affected by second-order uncertainty are climatic change, financial technology (fintech) and rare event estimation, to cite a few.

Professor Fabio Cuzzolin is a leader in the field of random set theory, a natural generalisation of probability theory able to model second-order uncertainty. His goal is to apply random set theory to achieve more robust foundations for machine learning, less sensitive climate change models, but also effective financial predictions and decision making in big data analytics.

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For further information on Uncertainty in Artificial Intelligence research:
www.brookes.ac.uk/ecom/research/computing/artificial-intelligence-and-vision/
Augmented Reality

The Performance Augmentation Lab (PAL) addresses three main areas of research:

- Human computer interaction: augmented reality and wearable technologies
- Software engineering: technology-enhanced learning, knowledge-based systems and job performance aids
- Data science: performance analytics

With Augmented Reality and Wearable Technology, it is possible to embed knowledge directly into what people experience, enriching the world beyond the visible to allow the creation of novel and powerful forms of feedback on performance.

It is the mission of the Performance Augmentation Lab (PAL) to extend the performance-relevance of HCI and research mixed reality interactive content in order to improve user experience and human performance.

Example applications include augmentation for aircraft maintenance engineers so they receive visual instruction and guidance for maintenance tasks. Augmentation for radiologists to improve radiotherapy treatment and support for astronauts in maintenance of equipment while in space.

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For further information on Performance Augmentation Lab research:
www.brookes.ac.uk/ecm/research/computing/
Electronics and Communications

Communications research
High reliability and availability communications will be required for future vehicular networks to ensure safe and efficient transport in all conditions. This group is investigating heterogeneous wireless communication techniques, where data can be switched to the best available wireless technology, or sent over multiple wireless technologies simultaneously, which can lead to improved performance.

The group is also researching into solutions for traffic monitoring based on the Internet of Things. Low energy sensor nodes, which can be embedded in the road or deployed on the roadside are being developed; and alternative low power radio technologies for backhauling data from these sensor nodes to the cloud are being investigated. This can be used for traffic counting, traffic profiling and also for informing vehicles about road conditions.

Electronics research
With people living longer, the aging population will have greater needs for healthcare. This, along with the greater focus on preventative medicine and continuous monitoring, has led to an increased demand for reliable and wearable biomedical monitoring equipment. The group is working on circuits and systems for continuously monitoring conditions such as breast cancer tumours and blood glucose levels, and developing techniques to detect/monitor skin cancer and leukaemia. Work is also being carried out on ways to improve the resolution of MRI scanners and methods to reduce the electrical noise picked up by biomedical electrodes.

The group is also investigating automotive electronics, including driver fatigue monitoring to reduce accidents, head-up displays, and enhanced sensor and control systems for autonomous vehicles.

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Outline research topics:
- Co-operative multi-user heterogeneous wireless system for communication in vehicular networks
- Secure IoT solutions
- High performance circuits for medical instrumentation
- Circuits and systems for biomedical applications
- Automotive electronics for safer driving

For further information on computing research:
www.brookes.ac.uk/ecm/research/computing/communications--media-and-electronic-technologies/