QUANTIC

The UK Quantum Technology Hub
in Quantum Enhanced Imaging

MAKING THE *INVISIBLE*, **VISIBLE**

Our mission is to connect world-leading scientists across UK universities with pioneering industry leaders to accelerate quantum innovation in imaging

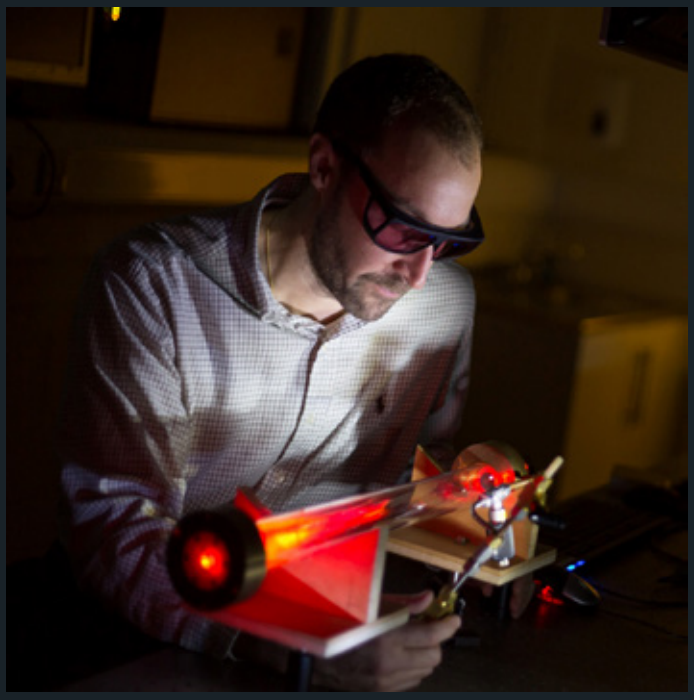
www.quantic.ac.uk

OUR MISSION

QuantIC aims to commercialise world-leading imaging research to pioneer a family of cameras operating across a range of wavelengths, timescales and length-scales, creating a new industrial landscape for imaging systems and their applications.

We combine single photon sensing with nonlinear optics, computational methods, and a range of specialised detectors to advance imaging technology.

Established in 2014, QuantIC is part of the £1b UK National Quantum Technologies Programme.
A dynamic collaboration between industry, academia and government designed to create a global centre of excellence for quantum science and innovation.



WORK WITH US

QuantIC's research programme is accessible to industry and new academic research groups through a £4M Partnership Resource Fund.

This collaborative fund offers an easy access, low-risk, mechanism for QuantIC to integrate with industrial products and processes, form new quantum technology-based ventures, and address large-scale industrial challenges through novel quantum approaches.

QuantIC also offers a fully funded Industrial Studentship Programme which is designed to develop both academic and technical excellence in the next generation of quantum engineers.

To discuss how QuantIC research in imaging can have an impact on your company contact **info@quantic.ac.uk**

OUR SUCCESS

QuantIC has contributed to the development of several technologies that have been successfully commercialised with industry partners.

QLM

Methane Gas Sensing

QLM Technology is a start-up company, founded by QuantIC researchers at the University of Bristol, which aims to mitigate greenhouse gas emissions through LiDAR technology.

QLM has developed drone mounted, quantum sensing technology capable of remotely detecting and quantifying minute methane leaks. This work was supported by QuantIC, through an EPSRC Impact Acceleration award, and the Quantum Technology Centre (QTEC) at the University of Bristol.

In 2023, QLM commercially launched its Quantum Gas Lidar and the QLM Cloud, an analytics platform for analysing and managing associated emissions data.
www.qlmtec.com

HORIBA Scientific

Wide field fluorescence imaging (FLIM) camera for biological microscopy

Horiba Scientific collaborated with QuantIC to incorporate the QuantiCAM Single Photon Avalanche Diode (SPAD) sensor into their existing fluorescence imaging system. The collaboration resulted in the development and launch of FLIMera, a new wide-field fluorescence lifetime imaging camera which is exceptionally faster than conventional scanning microscopes and enables the study of mobile samples, such as live cells and fluid biopsy for cancer screening.

Horiba Scientific were awarded the Institute of Physics Business Innovation Award in 2019 for the collaborative work with QuantIC in developing the novel FLIMera technology.

> "Partnering with QuantIC has made it so much easier for HORIBA to collaborate in diverse projects with leading research groups. Our FLIMera camera heralds new era in accessible, robust, fluorescence lifetime imaging based on the gold standard of single-photon counting."

David McLoskey, Managing Director,
HORIBA Jobin Yvon IBH Ltd

IMAGING THE FUTURE

Working with industry partners QuantIC has developed a range of active demonstrators that exhibit these next generation technologies. We are partnered with industry, and government bodies across the following sectors:

HEALTHCARE AND LIFE SCIENCE

QuantIC seeks to expand its contributions in biomedical imaging.

We are developing new optical cameras that could replace modern-day MRI and endoscopy equipment, and detect subtle differences in biological materials advancing tumour detection. More speculative work is combining single photon detection with machine learning to image through the body.

CLIMATE CHANGE

To tackle Climate Change, it is necessary for both industry and government organisations to have accurate, widespread access to monitoring solutions that can show the emissions, condition, and sustainability of our society.

QuantIC researchers have developed a range of quantum solutions that address major areas of climate impact. These include seeing gas emissions such as methane and hydrogen, structural health monitoring within challenging environments, and enabling improved product longevity and recycling capabilities through new spectral imaging for material sorting and quality control.

SPACE

Satellites and low orbit technology are vital for a wide range of terrestrial applications, from communications and weather system tracking to navigation and earth observation.

QuantIC's researchers produce high value components in small packages, enabling quantum solutions to be deployed in nanosatellites. These technologies take advantage of next-generation low power consumption, minimal background interference, and high sensitivity.

DEFENCE AND SECURITY

QuantIC are developing a range of cameras and sensors that will advance surveillance, navigation, and threat detection across defence and security settings. Quantum effects allow us to surpass conventional limits to reduce image noise or enhance image resolution - enabling covert surveillance from greater distances keeping us ahead of threats.

Quantum imaging can also provide an alternative approach to navigation informing location without reference to satellites. This allows organisations using quantum technology systems to remain effective under restrictive environments, improving covert activities, data-security, and resilience to electronic and cyber-warfare attacks.

TRANSPORT

Quantum imaging offers intelligent, and dynamic approaches for improving the safety, efficiency, and security of our transport networks, whilst reducing its impact on the environment, and budgets.

QuantIC cameras can track objects around corners or through hard-to-see heavy rain, snow and fog. This imaging technology will provide cities with improved traffic management, safer roads, more reliable public services, and usher a new era of autonomous vehicles. Quantum imaging research has simultaneously improved our capacity to manage the urban environment through crowd monitoring, remote scanning and emission level monitoring.

ULTRA-LOW NOISE SENSING

QUANTIC

University of BRISTOL

UKRI Engineering and Physical Sciences Research Council

Ultra-precise light measurements using quantum effects

Quantum technologies offer the greatest possible sensitivity of any device, providing us with more precise methods across a wide range of applications.

QuantIC researchers at the University of Bristol have developed a method of ensuring ultra-precise measurements for light sources, making the development of new, highly tuned optical systems achievable. Using quantum nonlinear effects (four-wave mixing) the team has designed an optical fibre capable emitting perfectly matching beams of visible light.

This approach suppresses any classical approach, which are 'shot-noise limited', and provides the ultimate level of accuracy allowed by quantum mechanics.

BENEFITS

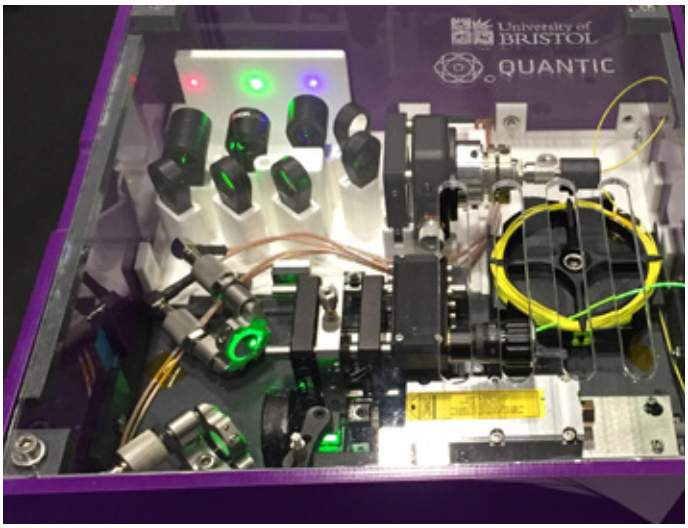
- The system is simple to use and highly stable
- Provides unique wavelengths and intensities compared to other systems

APPLICATIONS

- Enhanced biomedical imaging
- Precision sensing of light-sensitive samples
- High specification optical system certification

MEET OUR INVESTIGATOR

Jonathan C. F. Matthews is Professor of Quantum Photonics and Co-Director of Quantum Engineering Technology Labs at the University of Bristol. Jonathan's research focuses on integrated quantum photonics, quantum metrology, quantum walks and quantum information processing. He was awarded the 2021 Philip Leverhulme prize for physics. He and his team hold the current record for the fastest quantum noise limited homodyne detector.



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MEGAPROJECTOR

QUANTIC

University of Strathclyde Glasgow

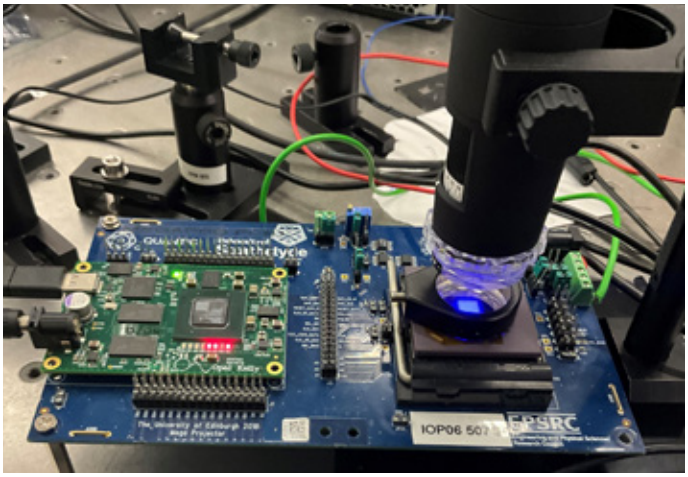
UKRI Engineering and Physical Sciences Research Council

World-leading microLED array

MegaProjector is a world-leading micro-LED (mLED) display, capable of displaying up to 1 million frames per second. By rapidly flashing an array of mLEDs, it is possible to transmit a vast amount of information through conventional lighting.

LEDs have all but replaced traditional lighting systems due to their numerous advantages in longevity, small size, and power-saving capabilities however recent developments have enabled them to be produced at even smaller scales, known as micro-LEDs. Researchers at the University of Strathclyde have created a mLED display that can be electronically controlled to reach ultra-fast framerates. Coupled with high sensitivity detectors, also pioneered through quantum research, MegaProjector can be deployed for several digital applications such as wireless communications through lighting (LiFi), and 3D mapping of a built environment.

MegaProjector researchers are also exploring its use for specialised systems such as ultraviolet communications, and structured biological imaging in microscopy.



BENEFITS

- Encodes data in both spatial and intensity, allowing ultra-high data transfer rates compared to other approaches
- Useable at micrometre to kilometre ranges, enabling a broad range of applications
- Utilises widespread LED-based technology so can be retrofitted to existing lighting infrastructure or high-resolution displays

APPLICATIONS

- Satellite and Free-Space datalinks
- Optical wireless communications (LiFi)
- Non-line-of-sight UV communications
- 3D and structured light image capture
- Single-pixel cameras

MEET OUR INVESTIGATOR

Martin Dawson is Professor and Director of Research in the University of Strathclyde's Institute of Photonics and is also Head of the Fraunhofer Centre for Applied Photonics. He has over 30 years' research experience in applied photonics gained in academia and industry and is recognised for his work on optically-pumped and ultrafast lasers, III-nitride optoelectronics and diamond photonics.

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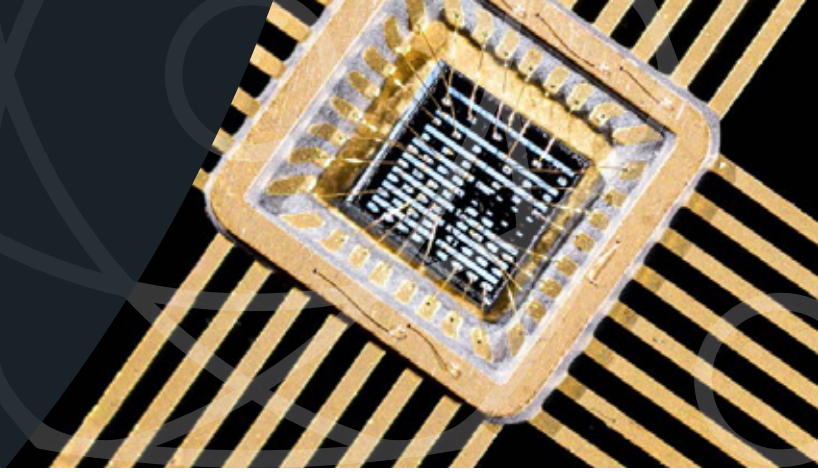
GERMANIUM ON SILICON SPADS



Quantum detectors for autonomous vehicles

LiDAR is a key enabling technology for several sectors including autonomous vehicles. It uses the speed of modern optical systems to accurately gauge the distance and map items around them by counting the reflection time from a flash of light. These LiDAR devices are heavily reliant on high quality detectors able to identify the low levels of light reflected, such as quantum single-photon avalanche diodes (SPADs). While SPADs are ideal optical devices for LiDAR, they are currently too expensive to implement for most commercial applications.

Using novel manufacturing processes, QuantIC researchers at the University of Glasgow and Heriot-Watt University are developing SPADs that can be produced at significantly lower costs. Based on affordable Silicon platforms, and Germanium to reach infrared wavelengths that allow eye-safe laser systems to be detected while imaging through rain, fog, and dust; QuantIC's next generation SPADs look to revolutionise the imaging world.

BENEFITS

- Capable of imaging through challenging scenes such as rain, fog, and dust
- Low-cost short-wave infrared detection
- Highly suited to LiDAR

APPLICATIONS

- Autonomous Vehicles
- Defence and Security
- High performance fibre optic detectors

MEET OUR INVESTIGATORS

Doug Paul is Professor of Electronic & Nanoscale Engineering at the University of Glasgow. With a grant portfolio of over £24M mainly concentrating on quantum technology with chip scale cold atom systems, MEMS gravimeters, Ge on Si single photon avalanche detectors, range-finding / lidar and single electron devices. He is a member of the UK Quantum Technology Hub in Sensors and Metrology / Timing, QuantIC (the UK Quantum Technology Hub for Quantum Enhanced Imaging) and the UK Quantum Technology Hub for Quantum Communications.

Professor Gerald Buller is leader of the Single Photon Research Group at Heriot-Watt University. His research interests are in single photon detection and its applications including quantum key distribution, quantum imaging, time-of-flight ranging and depth imaging.

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AI-ASSISTED IMAGING OF CONCEALED WEAPONS

QUANTIC

University of Glasgow

UKRI Engineering and Physical Sciences Research Council

Real-time, at range detection of concealed weapons for police and border security

The ability to detect concealed knives and firearms is of vital importance in many areas of policing and security, including airports, stadiums, nightclubs and schools. This pressing issue disproportionately threatens young and disadvantaged communities, while putting security personnel under increasing threat. While technologies do exist to identify concealed weapons and illegal items, these typically involve expensive infrastructure that operates at a single access point that limits coverage and disrupts day-to-day business.

QuantIC researchers at the University of Glasgow have developed an AI-assisted approach to combine information from numerous sensors that collectively produce a real-time, at range detection system. Scanning specifically for dangerous items, the device can ignore other metal-based devices such as mobile phones and watches while giving an accurate location of where the concealed weapon is.

The approach is low-cost and lightweight meaning it can be integrated onto police bodycams or doorways. High-speed scanning will remove queues and offer non-invasive security that informs greater stop and search approaches.

BENEFITS

- Security without queues and disruptive infrastructure
- Respects privacy - only identifies dangerous items with no 'through clothing images'
- Low cost
- Highly portable and small device that can be retrofitted easily
- Capable of scanning multiple individuals in a scene simultaneously

APPLICATIONS

- Airport security
- Police stop & search
- Defence and security
- Event and hospitality management
- Safety in public spaces and services e.g. hospitals and school

MEET OUR INVESTIGATOR

Professor Daniele Faccio is a Royal Academy Chair in Emerging Technologies, Fellow of the Royal Society of Edinburgh and Cavaliere dell'Ordine della Stella d'Italia (Knight of the Order of the Star of Italy). He joined the University of Glasgow in 2017 as Professor in Quantum Technologies where he leads the Extreme-Light group.

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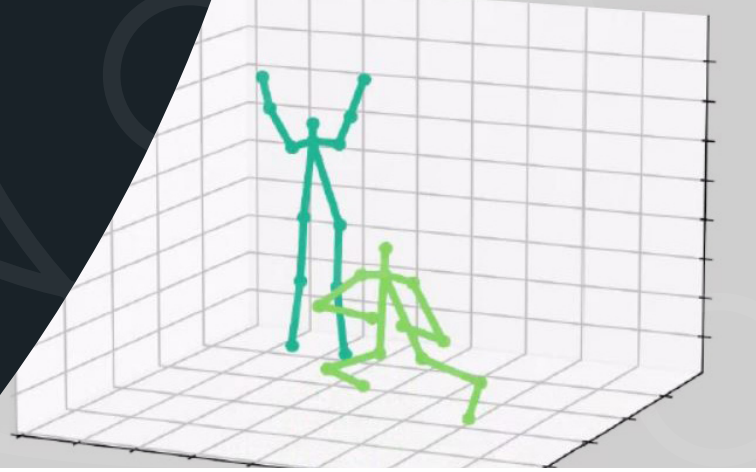
3D POSE DETECTION



QUANTIC

HERIOT WATT UNIVERSITY

UKRI Engineering and Physical Sciences Research Council

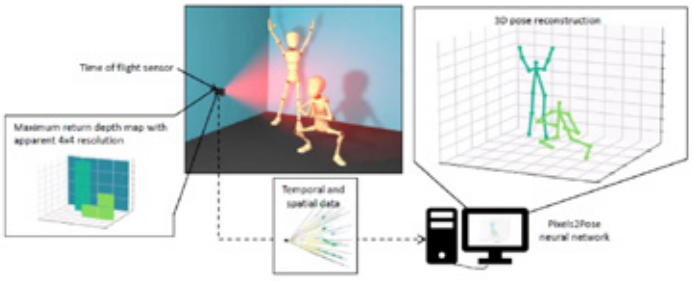
Real-time, low-cost pose detection for surveillance and autonomous vehicles

Pose estimation is a computer-based method to detect the position and orientation of a person or object. Researchers at Heriot Watt University have developed a machine learning approach for low-cost cameras to detect human poses.

The combined sensor and algorithm can determine 3D positions for multiple individuals using only 16 pixels in real-time.

Traditional 3D pose estimation requires advanced equipment and cameras to produce depth images.

The QuantIC 3D Pose Detection sensor uses computational imaging methods to achieve accurate pose estimation, transforming its data into accurate depth maps and 3D pose data of multiple people up to a distance of 3m from the sensor.



BENEFITS

- Low cost compared to traditional methods
- Can generate depth maps at a resolution of 32 x 32 and 3D localisation of body parts
- Use of simplistic sensors allow 3D recognition to integrate into numerous existing devices without additional cost

APPLICATIONS

- Robot interaction
- Surveillance
- Autonomous vehicles
- Augmented reality and virtual reality

MEET OUR INVESTIGATORS

Dr Jonathan Leach is associate Professor in the School of Engineering & Physical Sciences at Heriot Watt University. His research interests are in developing new classical and quantum optics techniques to solve problems in information science, optical sensing and imaging.

Alice Ruget is part of Heriot Watt University Quantum Optics & Computational Imaging group and works on computational imaging methods with deep learning to enhance the resolution of SPAD cameras.

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INDIPIX™ – Future Mid-Wave Infrared (MWIR) Detector

QUANTIC

University of Glasgow

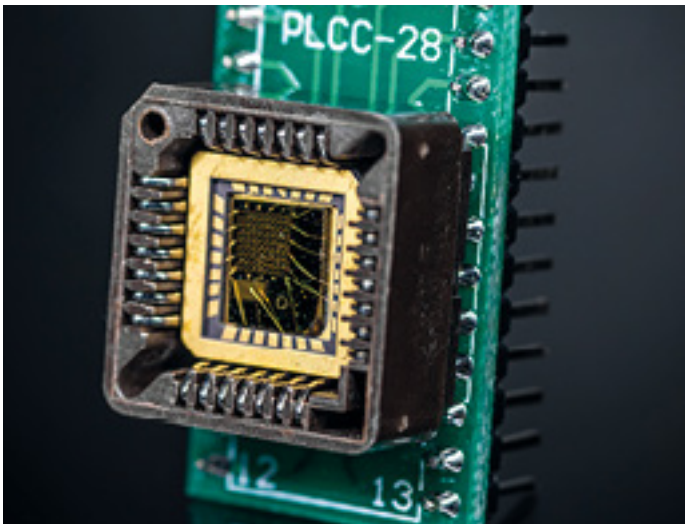
UKRI Engineering and Physical Sciences Research Council

New manufacturing processes provide cheap, high-volume MWIR detectors

Mid-wave infrared cameras offer numerous high-value applications, including greenhouse gas detection, thermal imaging for inspection and quality control, defence and security, and healthcare, however these cameras are extremely expensive to purchase and operate. QuantIC researchers have developed a new manufacturing process that dramatically reduces the cost of both production and operation of MWIR detectors.

IndiPIX™, produced by QuantIC researchers at the University of Glasgow, utilises gallium arsenide (GaAs) instead of a silicon-based readout chip to remove several manufacturing stages leading to reduced costs. Critically, IndiPIX™ removes the need for flip-chip bonding and minimises thermal expansion mismatch, core leads in the high cost and failure rate of MWIR detectors.

Lower-cost MWIR detectors will lead to significant mass-production and new applications as they become increasingly commonplace.



BENEFITS

- Significantly cheaper to manufacture using wafer-scale fabrication on large GaAs substrates
- Low failure rate due to a monolithic construction
- Potential to run without cooling, significant lowering operational costs, size, weight and power of devices

APPLICATIONS

- Greenhouse gas detection
- Health & safety (detection of harmful substances)
- Defence and security
- Material testing
- Cancer diagnostic
- Building Inspection

MEET OUR INVESTIGATORS

Professor David Cumming is Director of QuantIC and an internationally recognised leader in semiconductor sensors and microsystems. He is widely recognised for his work on CMOS biochemical sensor technologies. David is Professor of Electronic Systems at the University of Glasgow.

Dr Vincenzo Pusino is Lecturer in Electronic & Photonic Devices at the University of Glasgow. Vincenzo has over ten years of experience researching optoelectronics devices, in particular mid-wave infrared detectors and imagers based on antimonide materials.

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SINGLE FIBRE IMAGER

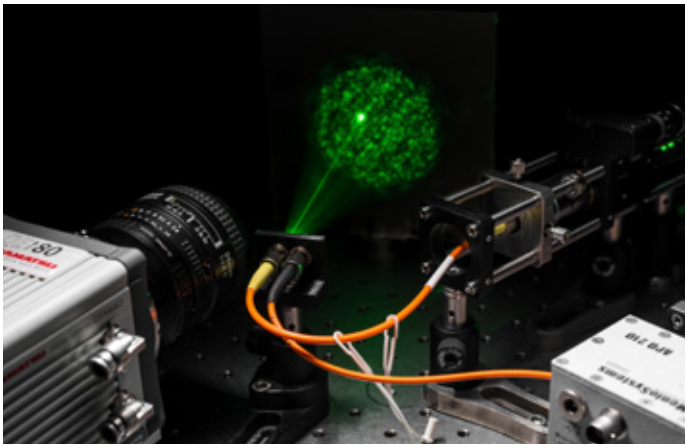
Imaging through an optical fibre, the width of a human hair

Optical fibres have revolutionised our data-centric world. It is the highway of our internet, television, and communication needs. Light is often used to transfer data, but not an image.

Traditionally to send an image inherently through fibres, such as in endoscopes, bundles of many thousands of optical fibres are needed, with one fibre for every pixel in the image. QuantIC's innovation has been to project a video through a single fibre.

Normally, when light shines through a single optical fibre it is scrambled, making the image unrecognisable. To resolve this, the team at the University of Glasgow reverse this process and use carefully shaped light at the input to create a single spot at the output. That spot of light is then rapidly scanned across the scene and captures each pixel of detail for a camera to record.

The technology has been demonstrated for a range of wavelengths allowing infrared and visible inspection or non-visible and eye-safe optics. Even 3D LiDAR imaging has been developed when using a pulsed laser input.



BENEFITS

- 3D imaging capability
- Millimetric resolution and real-time frame rates
- Non-invasive, ultra-low profile
- Robust fibre delivery for extreme, and highly sensitive environments
- Cost-saving and removes need for access points
- Customise to a range of needs

APPLICATIONS

- Healthcare - Medical diagnosis and Surgery
- Defence and security – Covert Imaging
- Manufacturing and Energy - Non-destructive Testing (NDT)
- Nuclear and Civils – Monitoring and Decommissioning

MEET OUR INVESTIGATOR

Professor Miles Padgett is Principal Investigator of QuantIC, Interim Executive Chair of the Engineering and Physical Sciences Research Council (EPSRC) and the Kelvin Chair of Natural Philosophy at the University of Glasgow with research interests spanning optics and quantum enhanced imaging and sensing.

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CASE STUDY:

DIGISTAIN

digistain

Quantum-enhanced breast cancer diagnosis technology to provide rapid and reliable answers to patients and consultants.

World-leading research by QuantIC in mid-infrared imaging has led to a start-up company, Digistain, delivering quantum-enhanced analysis to doctors so they can provide the best treatment for breast cancer patients. Traditional methods of diagnosing cancers involve assessing dyed samples of tissue by eye under a microscope, to diagnose the presence and severity of the disease. These tedious processes are subjective and can take weeks to deliver a result, resulting in increased patient anxiety, and medical uncertainty.

The Digistain diagnostic tool, developed by Professor Chris Phillips and Dr Hemmel Amrania at Imperial College London, analyses samples by measuring signature changes in the mid-infrared light attributed to cancerous cells. When incorporated into a computer program, the severity of the disease can be assessed in moments at a fraction of the cost.

Mid-infrared cameras have long been extremely expensive, and have several limitations due to their inherently noisy, unstable images. Quantum imaging enables infrared information to be transferred onto a visible RGB camera system using non-linear materials, allowing Digistain to produce ultra-high quality mid-infrared images for medical diagnose.

After a landmark trial with over 800 breast cancer patients, Digistain demonstrated the QuantIC developed tool produced results equivalence to the current gold standards and received Medicines and Healthcare products Regulatory Agency approval, meaning patients can now get the treatment they need more quickly.

Digistain has won a Royal Society Innovation Award and an Institute of Physics Business Start-Up Award for solving treatment delays in breast cancer.

Professor Phillips explains, "We hope Digistain imaging technology will be incorporated into existing hospital labs over the next few years, enabling radically faster breast cancer treatment decision-making for physicians and patients."

SUPPORT FROM QUANTIC

- Funding scientific development of Quantum non-linear imaging at UK universities
- Skills development in Quantum imaging with PhD studentship funds
- Providing networking and marketing opportunities
- Introduction to venture capital firms, and seed funding

Find out more: digistain.co.uk

QUANTIC

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OUR TECHNOLOGY & SERVICES

QuantIC provides a range of technologies and services to deliver quantum imaging solutions.

Quantum detectors

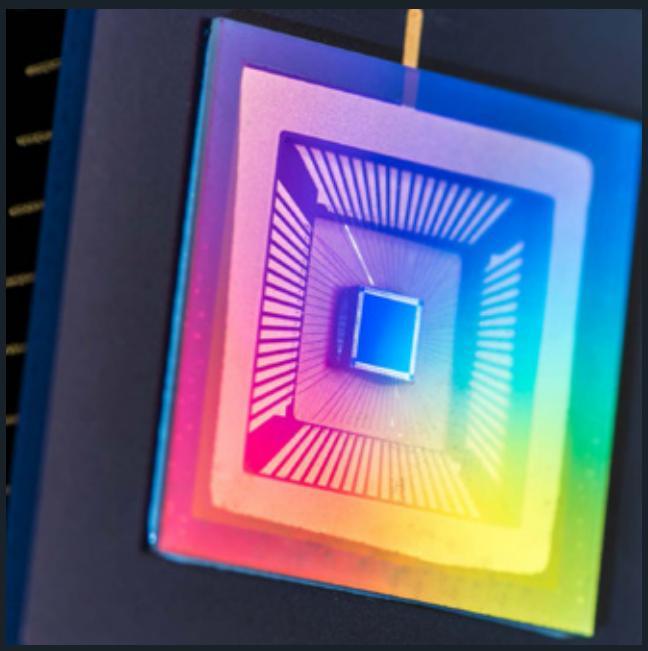
The design, fabrication, and testing of quantum detectors offers unparalleled capabilities. Devices such as Single Photon Avalanche Diodes (SPADs) provide incredible light sensitivity and high precision timing, used in technologies such as LiDAR and next generation cameras.

Novel optics

Utilising quantum mechanics and our broad understanding of light, QuantIC provides optics that allow us to image places and wavelengths never seen before. These include non-linear waveguides and fibre-optic technologies that enable new applications and enhance existing systems.

Structured & computational imaging

Machine learning and internet-of-things solutions for quantum cameras allows our technologies to intelligently use their hardware and data. This ensures ultra-low size, weight, and power devices at scalable costs.



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