BRISTOL
VISION INSTITUTE

World leader in interdisciplinary vision research

bvi BRISTOL VISION INSTITUTE

University of BRISTOL

Introduction

The University of Bristol is recognised as a world leader in vision research, spanning human and animal vision, artificial vision systems, visual information processing and the creative arts. Bristol Vision Institute (BVI) was formed in 2008 on the basis of strength across disciplines. It brings together some 170 associates from engineering, computer science, biological sciences, psychology, ophthalmology, history of art, film & television and medicine with the aim of addressing grand challenges in vision research.

BVI is one of the largest vision groups in Europe, and is unique worldwide in terms of its scope. It is particularly proud to host the only current EPSRC Platform Grant in vision science and engineering - Vision for the Future. BVI offers unequalled potential for progressing vision research in its broadest sense - from perception to application.

In this brochure, we present a small selection of the research that is ongoing in BVI. We hope you enjoy learning about our work.

Professor David Bull
BVI Director

Our challenge

It is estimated that about half of the cortical matter in the human brain is involved in processing visual information. This reflects the significance of vision for function and survival but also explains its capacity to entertain, challenge and inform. It further explains why we can build computers that beat us at chess (and even Go) but cannot yet emulate the complex processes that make up the human visual system.

Vision is central to the way humans and other animals interact with our world. For example: the mammalian visual system is used by cheetahs to implement stable locomotion at over 80 km/h, and by humans to thread a needle with sub-millimetre accuracy; the mantis shrimp uses 12 colour channels together with polarisation and it possesses the fastest and most accurate strike in the animal kingdom; fruit flies perform remarkable visual tasks at retinal bit rates of approximately 200 bits per second, compared to several millions of bits per second for most entertainment or surveillance systems. Video is THE key driver of the internet - YouTube video accounts for 25% of all internet traffic and, by 2019, CISCO predict that video will account for 86% of all traffic with total annual IP data traffic rising to 2 zettabytes. These examples highlight the significance of vision in terms of our fundamental understanding of the world and our interactions with it.

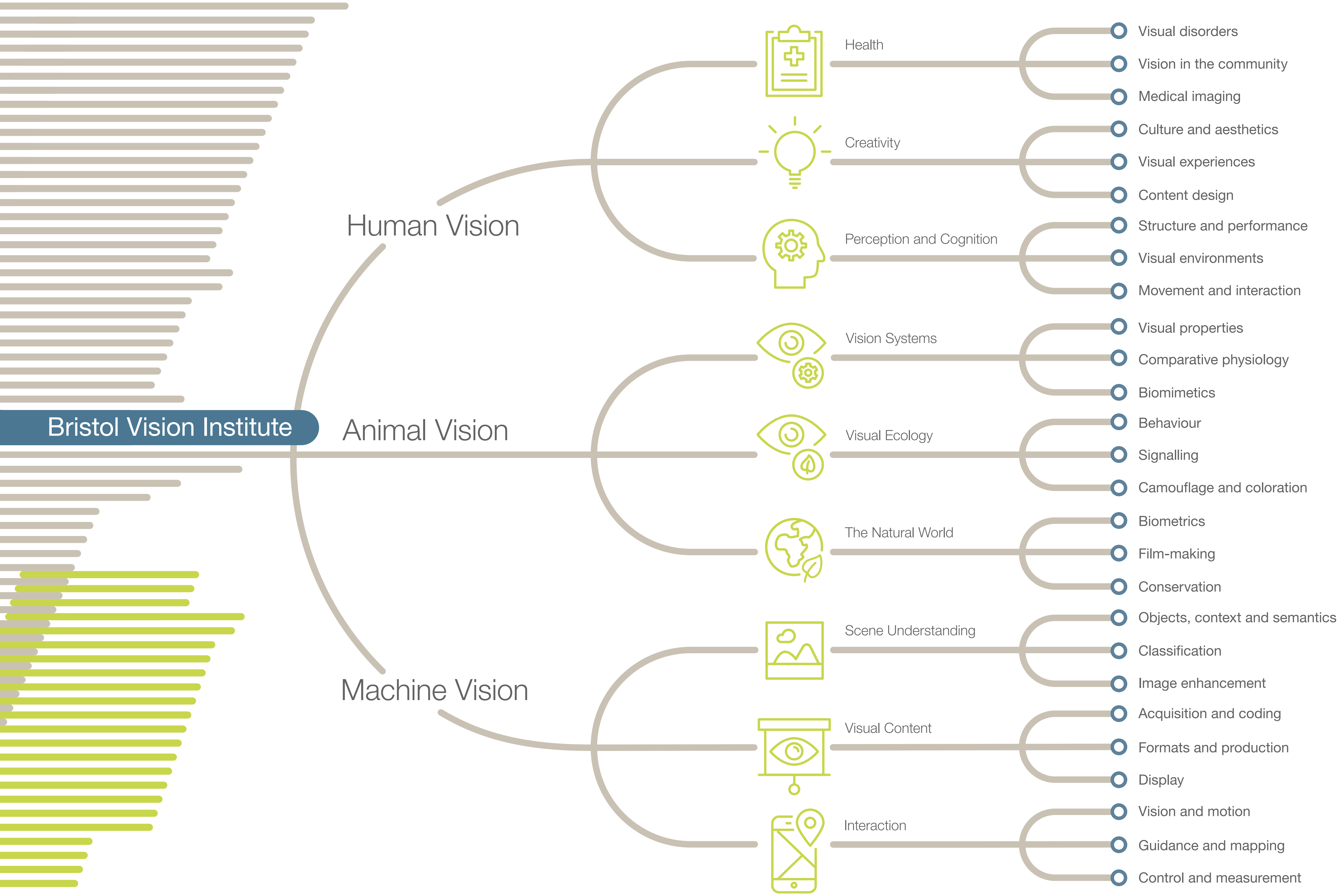
Outbreath See front cover

'Outbreath' is a life-size document of one two hundredth of a second in the growth and decay of the normally invisible turbulence trail formed during exhalation. It was created by local artist Mat Chivers in collaboration with BVI researchers Colin Dalton and Neill Campbell and with the BBC Natural History Unit. A small piece of solid carbon dioxide was placed in the hollow below Mat Chivers' tongue. As he exhaled, the solid C02 sublimated and became a gas that was visible in the carefully focused light of the laboratory. This constantly shifting and nebulous process was documented using three synchronised high speed digital cameras. Mat selected an archetypal image of this process then, by drawing on film stills from each of the three perspectives, he defined the surface of this event which was then transcribed into three dimensions to create a geometry that was constructed using rapid prototyping technology.

Our focus

BVI's primary focus is on developing a better understanding of the visual mechanisms and processes evolved in humans and other animals, and on translating these to innovations in technology, medicine and the creative arts. Our primary work programme spans three highly coupled themes:

- **Visual engagement** Only through measurement of immersion can we truly understand the influence of technology (display format, dynamic range, compression and viewing environment) on the creative process and user experience. This is essential, for example, if we are to understand the impact of emerging formats on cinematography and are to develop the next generations of camera and display technology.
- **Vision in motion** Our work links vision, body dynamics and the analysis of visual environments, with applications across autonomous systems, healthcare, rehabilitation and disease impact, and motion capture for rehearsal and animation.
- **Finding and hiding things** By better understanding biological vision systems and visual environments we will drive new solutions in visual search, scene understanding, quality assessment, surveillance, navigation, medical treatments and ophthalmology.



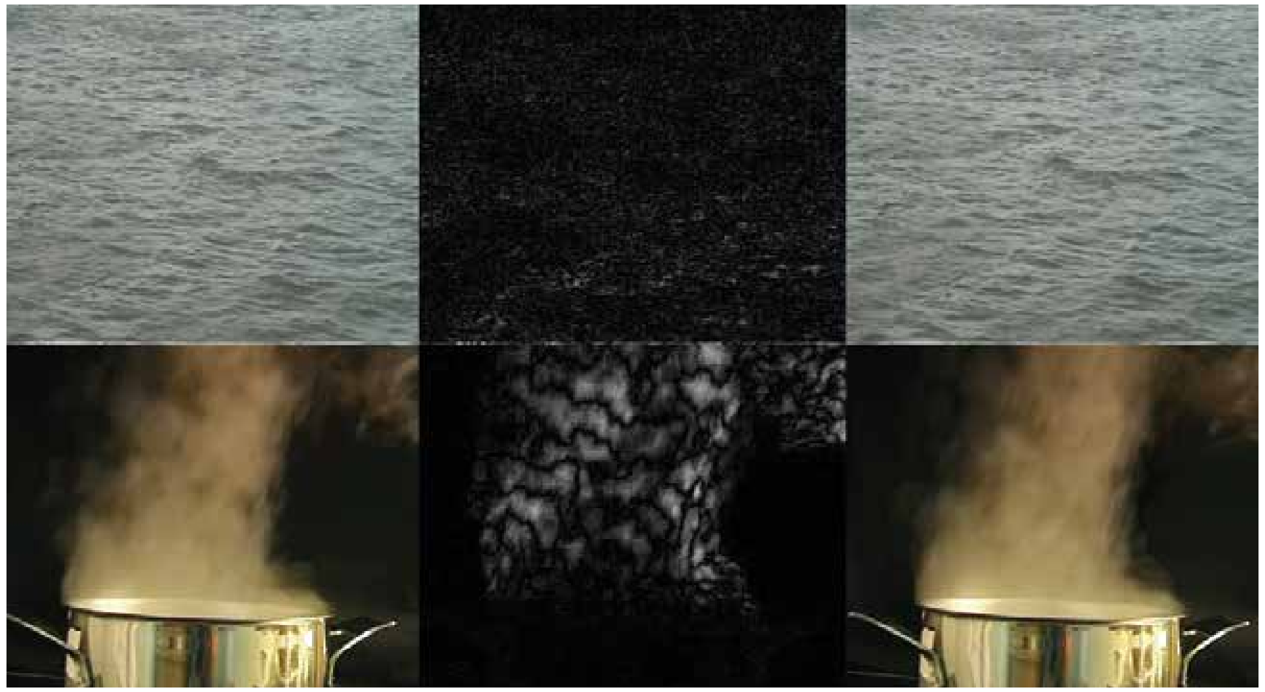
Bristol Vision Institute
Human Vision
Animal Vision
Machine Vision
Health
Creativity
Perception and Cognition
Vision Systems
Visual Ecology
The Natural World
Scene Understanding
Visual Content
Interaction
Visual disorders
Vision in the community
Medical imaging
Culture and aesthetics
Visual experiences
Content design
Structure and performance
Visual environments
Movement and interaction
Visual properties
Comparative physiology
Biomimetics
Behaviour
Signalling
Camouflage and coloration
Biometrics
Film-making
Conservation
Objects, context and semantics
Classification
Image enhancement
Acquisition and coding
Formats and production
Display
Vision and motion
Guidance and mapping
Control and measurement

Perceptual video compression

Visual experiences are key drivers, not just for the entertainment sector but also for business, security and communications technologies. CISCO predicts that video will soon account for over 80% of all internet traffic while mobile video access continues to rise by 100% year on year. These factors place increased demands on both communication networks and video compression.

The target of video compression is to provide good subjective quality rather than to simply produce the most similar pictures to the originals. Based on this assumption BVI researchers have conceived a compression scheme where an analysis/synthesis framework is employed rather than the conventional energy minimisation approach. This so-called parametric coding method employs a perspective motion model to warp static textures and utilises texture synthesis to create dynamic textures, similar to techniques used in computer graphics. The new algorithm offers significant potential for bitrate savings, compared to conventional methods. This work has spawned a major EU funded international collaboration (Provision) between Bristol, HHI Fraunhofer Berlin, The University of Nantes, The University of Aachen, BBC Research, Google YouTube, and Netflix to devise a future generation of video coding standards based on texture analysis and coding (David Bull, Aaron Zhang, Angeliki Katsenou, Mariana Afonso, Dimitris Agrafiotis Miltiadis-Alexios Papadopoulos, Thomas Ntasios).

One of the key challenges in video compression is how to measure the perceptual quality of a distorted image or video. Visual perception is highly complex, influenced by many confounding factors, not fully understood and difficult to model. Because the perceptual distortion experienced by the human viewer cannot be fully characterised using simple mathematical differences, BVI researchers Aaron Zhang and David Bull have developed a new Perceptual Video Metric called PVM. PVM simulates perception processes by adaptively combining noticeable distortions with measures of typical artefacts such as blurring and offers better correlation with human opinions than any of its competitors.



More immersive video formats

As the demand for higher quality and more immersive video content increases, the need to extend the current video parameter space, in terms of its spatial resolution, temporal resolution (frame rate), dynamic range and colour gamut, becomes ever greater.

For example, the use of increased frame rate can provide a more realistic portrayal of a scene through a reduction in motion blur, while also minimising temporal aliasing, and the associated visual artefacts, giving a greater sense of depth. BVI research led by David Bull, with Alex Mackin and Iain Gilchrist, in collaboration with BBC R&D (Katy Noland) has investigated the limits of human perception in terms of temporal sampling, discovering that critical frame rates up to 700Hz are possible, significantly higher than those in current use today. Furthermore this work has led to new adaptive methods that ensure perceptually optimised video acquisition. BVI has also produced the first publicly available high frame rate video database, containing 22 unique HD video sequences at frame rates up to 120 Hz.

Virtual futures

As part of a wider initiative to increase awareness of the potential of Virtual Reality (VR) technology in research and teaching, the University of Bristol (led by BVI's Andrew Calway) has been instrumental in establishing a new city-based laboratory designed to foster activity in VR across the region.

The Bristol Virtual Reality Lab (BVRL) is a collaboration with Opposable Games, Watershed, At-Bristol and the University of the West of England (UWE). Its mission is to provide a hub of expertise and collaboration on all aspects of VR and the related areas of Augmented and Mixed Reality (AR/MR). Bringing together local start-ups and developers, larger corporations and organisations, and those involved in teaching and research at the two Universities, the Lab will provide a forum for networking, collaboration, ideas generation and impact, for both commercial and research oriented activities. The Lab is located in the centre of Bristol and provides space for up to 40 researchers, developers and designers.

Measuring visual engagement

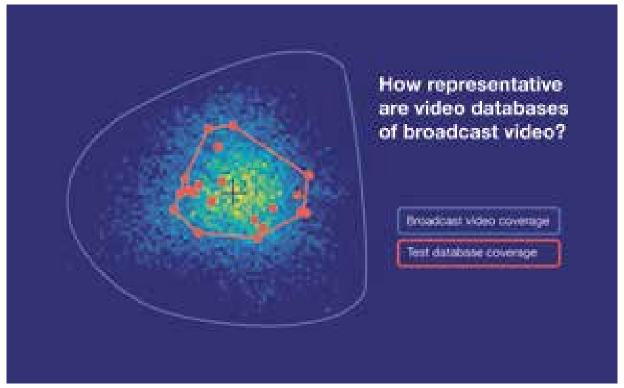
The visual world can be captivating: the sunrise over an ancient city, the spectacle of a high speed car chase, the tension as an interviewer cross-examines a slippery politician. For individuals and organisations making visual content (including television and films) an important question is: what makes some material engaging and some not?

BVI researchers Iain Gilchrist and Stephen Hinde (building on the early work of Tom Troscianko) have developed a suite of behavioural methods, based on physiological responses such as response time, to measure visual engagement. These have been carefully and rigorously validated to allow us to compare different cuts of a film or different display technologies in terms of their intrinsic immersive properties. This allows us to maximise visual immersion and engagement and, in turn, deliver the best visual experience for the user. It has been found that these methods are not only applicable to conventional visual media but are also applicable to gaming and developmental learning. Ongoing collaborative research with Lego and the University of Aarhus in Denmark and with BBC R&D is exploring this space.

What's really on TV?

In order to evaluate the performance of new video technologies, we need to understand and represent the full breadth of consumer video content.

The parameterisation of video databases using low-level features has proven to be an effective way of quantifying the level of diversity within a database of video sequences. However, without a comprehensive understanding of the relative frequency of these features in the content people actually consume, the utility of such information is limited.



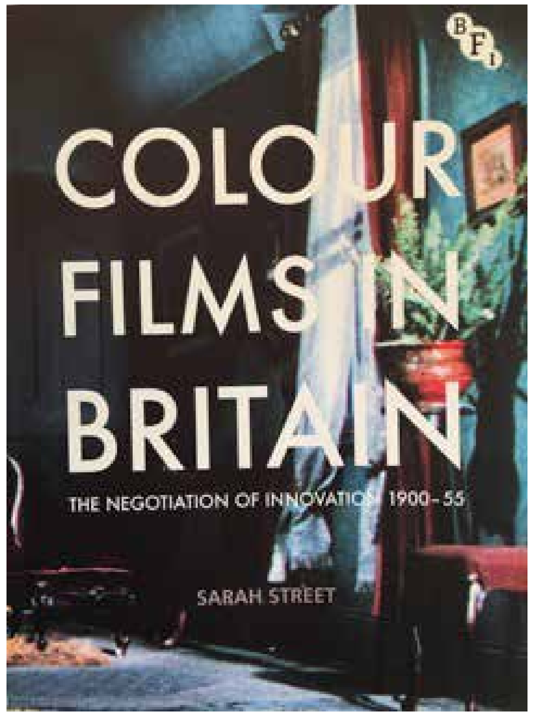
BVI researchers, Felix Mercer Moss, Roland Baddeley, Aaron Zhang and David Bull, in collaboration with BBC R&D, undertook a large-scale analysis of one year of programming on BBC One and CBeebies, the most popular television channels in the United Kingdom for adults and children, respectively. Relevant video features were extracted from almost three thousand television programmes shown throughout 2015 before principal component analysis was used to identify just five factors representing the most variation. The meaning and relative significance of these five factors, together with the shape of their frequency distributions, represent highly valuable information for researchers wanting to model the diversity of modern consumer content in representative video databases.

Driving distractions - BVI on the BBC One Show

Recent studies have indicated that reading and even writing text messages while behind the wheel is on the rise. The BBC One Show invited BVI researcher Felix Mercer Moss onto an airfield just outside Bristol to help perform an experiment to demonstrate the dangers of texting while driving.

A mobile eye tracker was used which revealed that drivers navigating the makeshift course spent as many as two seconds looking away from the road while replying to a text. The same drivers were then asked to wear a customised pair of 'black-out' goggles that simulated the degree of inattention measured on previous laps. The 'black-out' goggles caused carnage on the airfield and, in doing so, provided viewers with a stark reminder to keep their phones in their pockets when on the road.

Colours of the cinema screen



We take it for granted that modern films are made in colour and that they broadly reflect the world we see. Yet colour films dominated film production only in the silent era (1894-1929) and then did not again until the late 1960s. Research led by Sarah Street is examining the nature and impact of colour filmmaking in British, American and European cinema.

She has investigated how colour films were made, from the application of colour by hand, stencil or applied tinting and toning methods that characterise the silent era, to photochemical processes such as Technicolor, and the monopack stocks that enabled colour films to dominate sound cinema. Analysing the production and reception of a great variety of films made in different global contexts reveals that colour perception, understanding and appreciation are profoundly cultural phenomena influenced by prevailing aesthetic norms, national taste cultures and generic application. While new technologies often claim new capabilities, to a great extent, today's digital colour films follow the aesthetic conventions of past approaches to colour filmmaking. The research also links with film restorers and those concerned with the preservation of our colour film heritage.

Visual decision making and reasoning in an uncertain world

Humans, like any other animal, use vision to make decisions about the world. These decision can relate to what object is present in a scene, where it is, or the characteristics of the object: for example how fast is it moving, or how big it is.

Visual information is used to make decisions about how to act. The information that informs these decisions arrives over time, and so our level of certainty about the object may also grow over time too. BVI researchers Iain Gilchrist, Casimir Ludwig and Gaurav Malhotra, with funding from EPSRC have developed mathematical models of decision making that track the accumulation of evidence over time and allow us to model both what decision will be made and when that decision will occur. These models mirror the behaviour of individual neurons in the primate brain and provide an excellent description of human behaviour.

Follow your eyes

Humans move their eyes about three times a second. Eyes move to fixate on objects of interest and then quickly move on. They move primarily because visual acuity is very good in the central part of vision (the fovea) but reduces dramatically away from the current point of fixation.

We can only really see clearly what we are currently fixating. When the eyes are stationary on an object, visual information about that object is gathered. However, at the same time the limited vision capability in the periphery of our visual field is used to decide where to look next. BVI researchers, including Roland Baddeley, Iain Gilchrist, Ute Leonards and Casimir Ludwig have a long tradition of recording eye movements as a basis for understanding visual behaviour in both humans and animals. Understanding this active vision process is central to our fundamental understanding of human vision, as well as allowing us to scale up our knowledge to address more complex applied visual problems. As well as its fundamental research contributions, BVI's eye tracking work has found applications in product placement, robotic guidance and in assessing visual immersion.

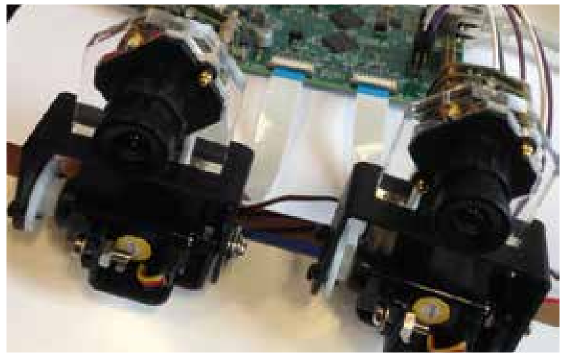
Vision for autonomous locomotion

Numerous scenarios exist where it is necessary or advantageous to classify terrain at a distance from a moving forward-facing camera. For example, image based sensors can be used for assessing and predicting terrain type in association with the control or navigation of autonomous vehicles or robots.

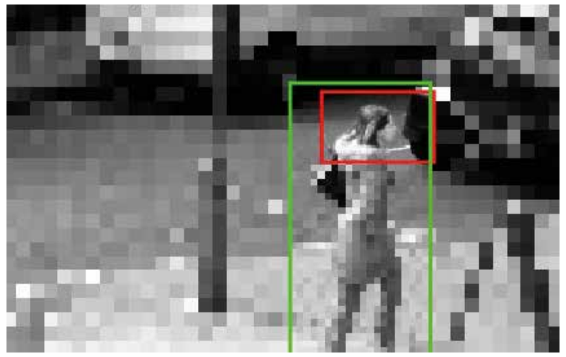
Upcoming terrain may be sloping, slippery, rough or present other characteristics that would result in a platform needing to change speed, direction or gait in order to ensure safe and smooth motion. BVI researchers Pui Anantrasirichai, Jeremy Burn, Iain Gilchrist and David Bull have produced an integrated framework to help solve this problem. Addressing issues such as motion blur and perspective distortions, the team has developed robust texture features that improve the performance of a terrain classifier based on monocular video captured from the viewpoint of human locomotion. This research is particularly important for biped robots or for humans with visual impairments and takes account of gait where probabilities of path consistency are employed to improve terrain-type estimation.

Computational cameras

Embedded and robotic vision systems of the future will need to be flexible with very low size, weight and power characteristics. Inspired by the capabilities of biological vision systems in nature, a novel computational camera has been developed by BVI researcher David Gibson in collaboration with Neill Campbell and David Bull.



The unique close-to-sensor design supports a flexible, very low latency interface between the image sensor and a highly parallel processing architecture. In particular, the design allows region of interest (ROI) adaptation where regions of the scene that contain little or no useful information can be discarded close to the sensor, reducing the transmission bandwidth and memory requirements. Pixels or regions can be spatio-temporally sampled according to the requirements of the scene and/or the task being performed. The system has attracted significant commercial interest world wide and is applicable to challenging areas such as visual navigation in UAVs, binocular robotic vision and, in particular, as a compact surveillance camera with embedded intelligence. A highly integrated modular version of the system has been produced that also includes a gyroscope, accelerometer and e-compass.



Visual mapping and location estimation

BVI researchers Andrew Calway and Walterio Mayol-Cuevas have developed efficient and robust algorithms for Simultaneous Localization And Mapping (SLAM). Visual SLAM is a technology that provides fast accurate 6D pose estimation of a moving camera and a 3D representation of the scene observed with the camera.

Specifically, their work has focused on the use of a single hand-held camera as a unique sensor, determining how to extract a rich representation of the environment using the map generated by the system and the visual information obtained with the camera.

The team have developed methods to identify planar structures from the environment based on a point-cloud representation generated by the SLAM system together with the appearance information contained in the images captured with the camera. The method evaluates the validity of points in the map as part of a physical plane in the world using a statistical framework that incorporates the uncertainty of estimations for both camera and the map obtained. This creates a better visual representation for mapping. This work has been widely applied in areas including: navigation in GPS-denied environments, virtual augmentation of objects in video footage, video-game interactions, robotics and UAV guidance.

Seeing CLEARly through turbulence

Atmospheric distortions, due to fog or haze, or turbulent mixing due to temperature variations can severely influence the visual quality of content acquired. For example, temperature variations can change the interference pattern due to light refraction causing unclear, unsharp and 'wobbly' images of the objects in the scene. These effects make the acquired imagery difficult to interpret or classify.

BVI researchers Pui Anantrasirichai, David Bull and Alin Achim have devised a novel and powerful method (CLEAR) for mitigating the effects of such atmospheric distortions, particularly the difficult case of airborne turbulence. In order to provide accurate details from objects behind the distorting layer, the least distorted regions are selected, and spatially aligned. The distortion problem is then solved using region-based video fusion. The combined result has been internationally recognised as delivering state-of-the-art performance and commercial exploitation is underway with a major US industry partner.

Activity and routine analysis

The visual understanding of actions, activities and higher-level behaviour such as daily routines is one of the most challenges problems in computer vision. This is because we, humans, perform tasks in very different ways depending on how busy or focused we are.

Consider, for example, the many ways that coffee can be prepared in the morning, the sorts of interruptions that might occur during the process and how this process might differ from one person to another. BVI researchers led by Dima Damen in the Visual Information Laboratory have created an analytical framework that can perform this type of analysis in industrial settings and in smart homes of the future from both static and wearable cameras.

One particular aspect of the work is focused on the visual analysis of routine - defined as the frequent and regular activity patterns over a specified timescale. Long-term unscripted routine patterns were captured using silhouette and depth imagery and characterised using a Dynamic Bayesian Network processing spatial location and pose alongside time envelops to encode durations where activities are common. Unlike traditional supervised models, the work automatically selects the number of hidden states for fully unsupervised discovery of a single person's routine. This work has many applications including more automated monitoring and assistance of our aging population in smart home environments.

How does the brain do vision?

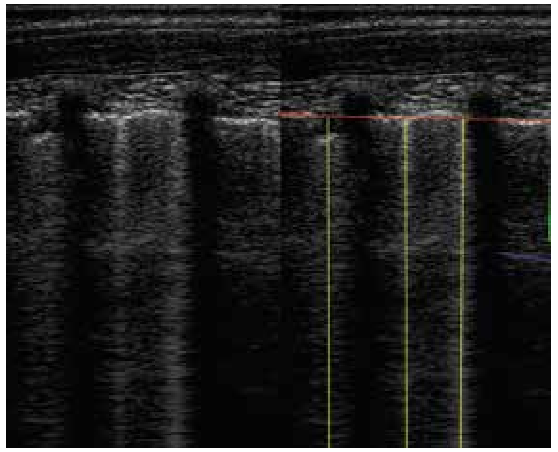
Of all the senses, vision is the one that dominates our ability to connect with and comprehend the world. For most of us vision appears to be effortless - we open our eyes and see. The ability to recognise an object, for example, your coffee mug regardless of the lighting, viewing angle and distance is a complex computation problem. This complexity is clearly revealed when we build artificial systems to do such tasks.

The human visual system has a complex network of brain areas that are specialised for vision. Within this network there is also clear evidence for regions that carry out sub-components of the problem. For example, there are brain areas that are selective to the location of the object, its colour, motion or form. BVI in conjunction with the University of Bristol Centre for Research in Clinical Imaging (CRIC) are gaining insights into this fractionation of function by studying patients with visual disorders using a range of brain imaging methods (MRI, EEG, MEG). Such studies allow us to explore the neural basis of vision as well as understand better how to diagnose and treat patients with pathologies of the brain that affects vision.

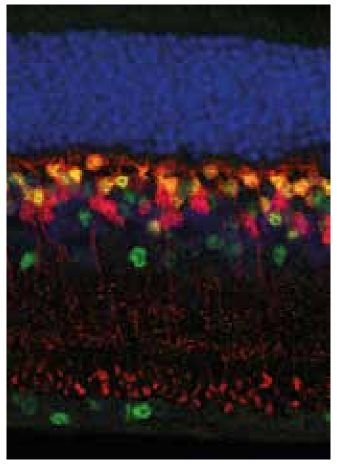
Understanding medical images

Children receiving dialysis need to have their optimal target weight evaluated very accurately but this is an extremely difficult task because of the lack of reliable means of assessing total body fluid status. Clinical studies have determined that for adult patients, a sensitive measure of fluid overload can be obtained through the use of lung ultrasonography to identify types of vertical lines in the image, whose number can be related to the amount of fluid that surrounds the tissue cells of patients. Automatically quantifying the number and type of these so-called B-lines using computer assisted techniques remains a significant challenge.

In order to address this challenge, BVI researchers Alin Achim and Pui Anantrasirichai, in collaboration with Wesley Hayes at Great Ormond Street Hospital and Marco Allinovi at the Meyer Children Hospital, Florence, Italy, have developed advanced methods for enhancing ultrasound image quality and for information extraction. By exploiting sparse approaches to image representations, coupled with state-of-the-art optimisation techniques they have developed sophisticated line detection techniques which differentiate B-lines from other types of line artefacts occurring in lung ultrasound images. This work, supported by the Welcome Trust, enables clinicians to accurately determine the appropriate amount of liquid to be removed from children under dialysis.



Visual disorders and retinal development



Our vision does not depend solely on the simple detection of different patterns and wavelengths (colours) of light. Our eyes sense the environment around us and our brain interprets this information to make judgements about the nature of objects, their position in space, movement, significance and familiarity to us.

The human eye is designed to focus light onto the retina. The light-sensitive cells of the retina are rod photoreceptors, responsible for night vision, and cone photoreceptors, responsible for colour vision and reading. These photoreceptors convey information to nerve cells in the retina that are much like nerve cells in the rest of the brain. Regarded as part of our central nervous systems, the neural circuitry of the retina provides some insight into how the brain works. The image shows light sensitive photoreceptor cells in the mammalian retina (blue), different types of nerve cells that connect with the photoreceptors and process colour and luminance information (red, green, yellow) and the organisation of the synaptic layers in the retina (red lamination).

The Human Genome Project has informed scientists about the DNA sequences that instruct the developing embryo to form a normal visual system. We also know about some of the differences between individuals in their DNA code that influence normal variations, such as iris colour and refractive error (short or long-sightedness). An individual's DNA can now be sequenced to work out their future risk of eye disease or the cause of an inherited visual disorder. BVI researchers led by Denize Atan are investigating the identity and function of genes that influence the normal development of our eyes and visual system, and what happens to our vision when these genes are faulty. This research is particularly focused on understanding the wiring of neural circuitry within the retina and what this can tell us about the rest of the brain. By taking a molecular approach and looking inside cells and our DNA to identify the processes that influence our vision of the world, this research hopes to further our understanding of retinal development.

Child health, development and vision

The detection, diagnosis and management of vision problems in children is a key challenge, particularly in the context of other developmental conditions.

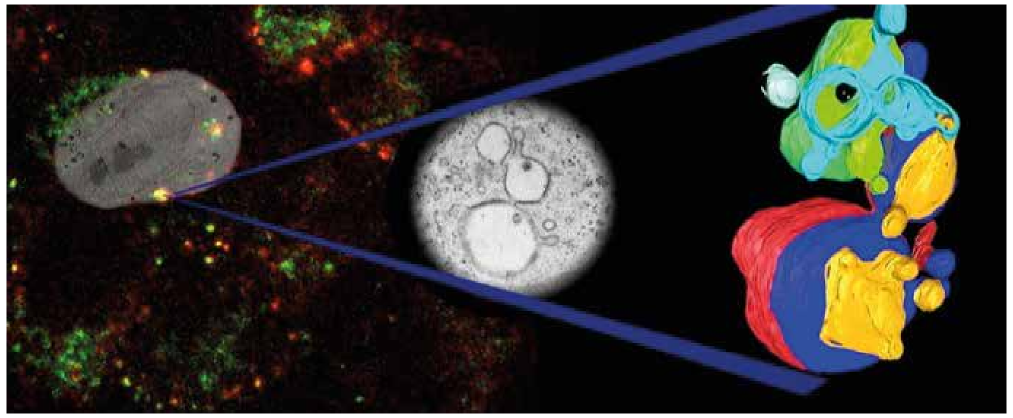
BVI academic Cathy Williams, funded by a prestigious NIHR Senior Research Fellowship, is undertaking a systematic review of interventions for children with vision and other problems, including analysis of optic nerve morphology, assessment of cognitive visual function, nutritional predictors of visual function, and eye movement studies. The research has also piloted a game for children with visual field loss.

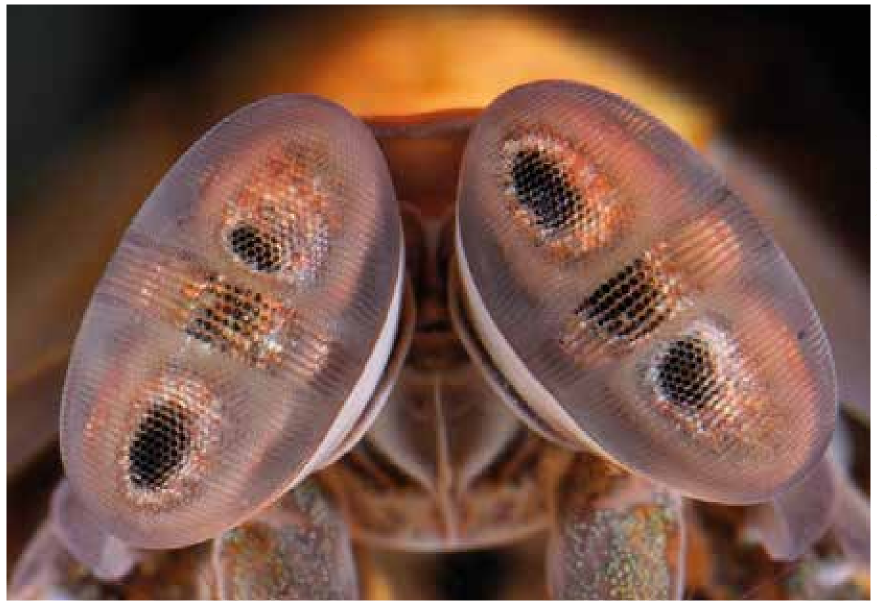
Alexandra Creavin, Cathy Williams and Colin Steer (and Raghu Lingam from Newcastle University) conducted the first large scale study in the world to assess vision abnormalities in a population-based cohort, studying almost 6,000 ALSPAC (Avon Longitudinal Study of Parents And Children) participants, investigating links between visual function and dyslexia. The work showed that the majority of children with severe dyslexia had normal vision and that the few impairments found also occurred in non-dyslexic children. This indicated that dyslexia is not primarily a vision problem and that vision-based therapies (like coloured filters or lenses) are not justified or likely to help.

Bioimaging at the cellular level

The beauty of imaging cells and cellular structures is combined with powerful image analysis methods in the University's Wolfson Bioimaging Facility. Paul Verkade, Head of the Electron Microscopy (EM) unit in this Facility has combined his own expertise on cellular trafficking, with image processing research in BVI (Alin Achim, David Bull, Paul Hill and Pui Anantrasirichai) to further our understanding of cell structures and dynamics.

The work of Verkade's group is world-renowned for its work on Correlative Light Electron Microscopy (CLEM), where the history of an event in live light microscopy is combined with high-resolution structural EM data of that same event. Mapping those two datasets onto each other has been a major challenge. Automated registration and mapping software developed within BVI has recently transformed the way we can perform CLEM experiments. Other example contributions include analysis of the 3D ultrastructure of insulin granules inside islets of Langerhans and the identification of fusion and segregation events inside cells by live light microscopy. As our microscopes continue to produce ever more information-rich data, the analysis and understanding of this data will rely even more heavily on advanced image processing methods.





The impact of the visual environment

Walking is the 'nearest activity to perfect exercise', improving our physical and mental health, furthering social interactions and, ultimately, our well-being. Yet few people walk sufficiently to gain these benefits. What could encourage people, in particular older citizens, to walk more? Some environments seem to support active travel while others discourage people from venturing into them.

Based on the fundamental role vision plays in human behaviour, BVI researchers led by Ute Leonards and Dima Damen are investigating the impact that the visual make-up of built environments has on our ability and willingness to move in them. This work is being conducted in close collaboration with Todd Handy (University of British Columbia), Arnold Wilkins (University of Essex), architect Steve Maslin (the Schumacher Institute for sustainable systems), artist Shelley James, the UK Collaborative for Research on Infrastructure and Cities (UKCRIC), and Bristol City Council. Early work supported by the Wellcome Trust and the BRACE charity provided evidence that floor patterns influence people's walking trajectories and that even movements of the lower limbs themselves are affected by distracting floor patterns. Understanding the relationship between our visual environment and our behaviour will help to tackle a major societal and public health challenge: how to create more inclusive, healthy and accessible environments for our ageing population.

Understanding animal vision

Some birds can see ultra-violet light, insects often see in (almost) 360 degrees, flying insects sense how the world is moving without seeing an image, and deep sea fish are sensitive to even the very smallest amounts of light. We often forget that other animals see their world very differently from us, and that such seemingly improbable visual abilities are common throughout the animal kingdom.

Research in BVI (School of Biological Sciences) focuses on one particular widespread and remarkable visual ability, polarisation vision. Polarisation describes how waves of light travel, and being able to see and manipulate the polarisation of light is a considerable advantage.

BVI Researchers Martin How and Nicholas Roberts have discovered several new ways animals see polarisation to improve visual contrast, use eye movements to enhance visual information, and how animals use and create visual signals. Liquid Crystal Display technology developed in BVI to measure how animals (including humans) are able to see the polarisation of light has now been adopted around the world for studying animal behaviour. This, along with our new camera developments, is being used to illustrate how animals see and to enhance our understanding of how animals really see in their own visual environment. This work has been performed in collaboration with various industry partners, film companies and corporations such as the BBC. It has also led to the creation of new methodologies and tools to evaluate the performance of different forms of camouflage in different animals and humans.

Polarisation vision in humans: preventing eye disease

Age-related macular degeneration (AMD) is the leading cause of blindness in the western world. With over two million people in the UK affected by AMD, the disease causes a serious visual impairment for more than half a million people. Recent research in BVI (School of Biological Sciences) has led to the development of a new device that can be used to test people's risk of AMD.

BVI researcher, Nick Roberts received funding from BBSRC which led to discoveries about how animals see polarised light. Nick Roberts and Shelby Temple realised that the experimental technology they had developed could be used to learn more about how humans detect polarisation, making the important link to AMD. The team were then awarded SETsquared ICURe funding from Innovate UK and HEFCE, which enabled them to conduct market research and business development. In 2016, the invention was patented and since then, Temple has continued to develop the device through his start-up Azul Optics, which will commercialise, produce and market the technology.

Camouflage in nature and war

Camouflage, whether the product of technology or evolution, is as much an adaptation to the perception and mind of the viewer as it is to the environment. In nature and war, concealment may be necessary against a foe with infra-red, ultra-violet or Polarisation vision, at ultra-high spatial or temporal resolution, and perhaps with hyperspectral colour dimensionality.

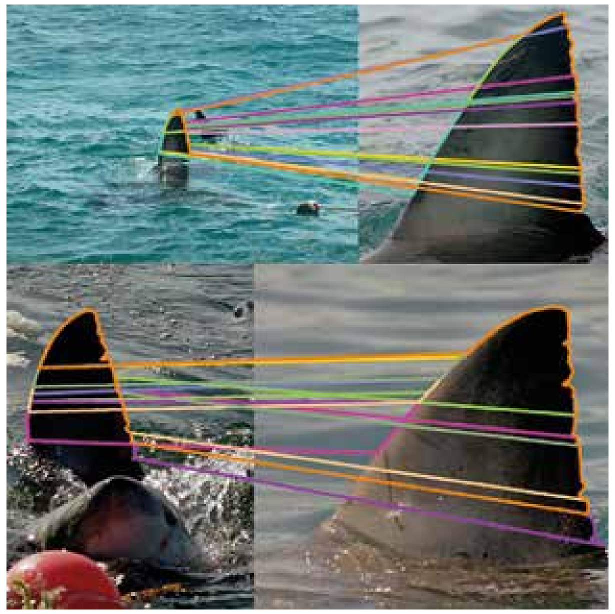
Understanding evolution's responses to the problems of defeating detection and identification by such foes, and how the human mind segments, recognises and tracks targets when those targets resemble the background, are core intellectual challenges for BVI biologists (Innes Cuthill), psychologists (Roland Baddeley and Nick Scott-Samuel) and computer scientists in www.camolab.com.

Military and animal coloration must often satisfy other constraints, in terms of recognisability and physical robustness. Understanding these trade-offs will lead to biologically-inspired solutions, underpinned by theory, for optimising concealment (or conspicuity) in both military and civilian contexts.

Visual biometrics

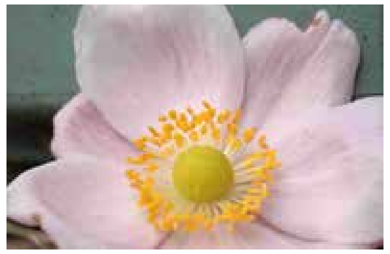
Research in BVI led by Tilo Burghardt, aims at providing non-invasive approaches to assist with problems in field biology – for example, to better understand and conserve endangered species. Specifically, the team has developed approaches that facilitate remote monitoring and identification of individual animals in large populations using computer vision and biometric techniques.

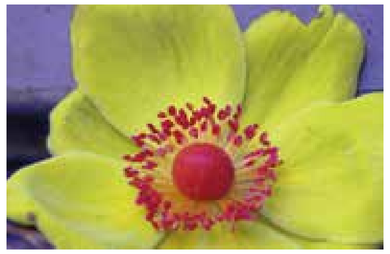
Building on experiences from proof-of-concept work on visual lion tracking, early work supported by the Leverhulme Trust demonstrated that sub-populations of African penguins could be recorded in their natural habitat enabling individuals to be identified visually by their coat markings. More recently, this concept of 'animal biometrics' has been used to help monitor other endangered species such as great apes and sharks. In the latter case, the biometric is based on the characteristics of the shark's dorsal fin. If high-quality imaging is possible and animals carry sufficiently complex markings, this approach works very robustly in dealing with different scales, viewpoints and even partial occlusions. The SaveOurSeas Foundation has recently started building on this research by integrating the developed white shark software with the global online platform Wildbook in order to allow researchers to submit shark fin photographs and match their sightings against large population databases. Animal biometric systems for great ape research are currently being developed further with German collaborators including the Max Planck Institute for Evolutionary Anthropology in Leipzig with the goal of large scale application to camera trap footage.



Visual signalling in animals and plants

For a complete understanding, colour in nature must be studied from multiple perspectives. The mechanisms of colour production include not only pigments, but also the properties of cell surfaces and structures within insect body coverings such as skin, hair, feathers and cuticle.





These properties underlie the intense, direction-dependent and hue-changing iridescent colours seen in a hummingbird's throat patch or a jewel beetle's wing cases. How such colours are produced raises fascinating research questions ranging from the photonics of production to their function and evolution. BVI researchers Nick Roberts, Heather Whitney, Innes Cuthill and Nick Scott-Samuel are investigating these topics through modelling of visual perception and cognitive mechanisms such as learning and memory, in the receivers of the colour signals, whether intended (e.g. a mate to be impressed) or not (a predator seeking prey). This integrated approach also sheds light on important applied questions ranging from plant-pollinator ecology to the design of warning signage in urban environments.

BVI Inspirations

Richard Gregory (1923-2010)

Richard Gregory FRS CBE was a polymath, a great interdisciplinary thinker and an inspiration behind BVI. Richard was Professor of Neuropsychology at Bristol and Director of the Brain and Perception Laboratory. He was founding editor of the journal "Perception" (1972) and also a founding member of the Experimental Psychology Society, serving as its President in 1981-2. In 1978, he founded The Exploratory, an applied science centre in Bristol - the first of its kind in the UK. He authored and edited several books, most notably Eye and Brain (published in 1966 and still in print today) and Mind in Science. In 1967 he delivered the Royal Institution Christmas Lectures on The Intelligent Eye. He was also a guest on Desert Island Discs.

One of Richard's passions were visual illusions and what these revealed about human perception. He is well known for his explanation of the café wall illusion.

Richard's achievements were recently recognised by the City of Bristol through the award of a Blue Plaque which is mounted on the Workhouse Kitchen above the Cafe Wall Illusion in Bristol at the bottom of St Michaels Hill.

Tom Troscianko (1952-2011)

Tom started his career as a lab technician in the British Steel Corporation (1970-71). Then, after a Physics degree from Manchester University he became a Research Scientist at Kodak, where his interest in colour vision began. After a PhD in Optometry and Visual Science (1975-78), he moved to Bristol University in 1978 to work on hearing and vision with Richard Gregory. His many contributions include work on 'isoluminance' and its effects on the perception of form and motion and computational modelling of vision. He organised the European Conference on Visual Perception in 1988 and became a Lecturer in 1991. After a spell at the University of Sussex, he returned to Bristol as Professor of Psychology, and founded the Cognition and Information Technology Research Centre (COGNIT) whose aims, like Tom's, were to foster an interdisciplinary approach to cognitive neuroscience. Tom and COGNIT were an inspiration for BVI and he was a key member of the management team.

Contact

BVI has a number of collaborations with local and global organisations and can be a gateway for your organisation into the University and to our network of academic and non-academic collaborators.

Further information on BVI led research, our regular interdisciplinary seminars and public lectures can be found on our website.

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