Bristol Vision Institute

World leader in interdisciplinary vision research

We focus on understanding the visual processes and mechanisms of humans and animals; and how these can innovate technology, medicine, and the creative arts.

IMAGE BY M.BOK

// The challenge

Vision is central to how humans and other animals interact with the world. For example:

- About half the human cortex is involved in processing visual information
- Video is the key driver of the internet. YouTube video accounts for 25% of all internet traffic and CISCO predict that, by 2019, video will account for 86% of all traffic, with total annual IP data traffic rising to 3 zettabytes
- Cheetahs use their visual system to achieve stable locomotion at over 80 km/h
- Mantis shrimp use 12 colour channels, together with polarisation; and have the fastest and most accurate strike in the animal kingdom

// Our focus

Our primary work programme spans three closely associated themes:

Visual engagement
Through measuring immersion, we can understand the influence of technology (display format, dynamic range, compression, viewing environment) on the creative process and user experience. This is essential to understanding the impact of emerging formats on cinematography; which in turn is essential to developing the next generations of camera and display technology.

Vision in motion
Our work links vision, the dynamics of the human body, and how people analyse their visual environment. Alongside healthcare, rehabilitation and disease impact applications, this has applications across autonomous systems, and motion capture for rehearsal and animation.

Finding and hiding things
By better understanding biological visual systems and visual environments, we can drive new solutions in:

- Visual search
- Scene understanding
- Quality assessment
- Surveillance
- Navigation
- Medical treatments
- Ophthalmology

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To measure performance of new video technologies, we need to understand the full breadth of what we watch on television.

// Driving distractions

An effective way to measure the diversity of what we watch is to analyse the low-level visual features of video databases. However, this information is more useful if we understand the relative frequency of these features in the TV content that people actually watch.

BVI on the BBC One Show

Reading and writing text messages while driving a vehicle, is on the rise. BVI researchers went on the BBC One Show to demonstrate the dangers of texting while driving. Filming took place on an airfield just outside Bristol, in which drivers navigated a makeshift course.

A mobile eye tracker was used to show that drivers looked away from the road for up to two seconds, when replying to a text. The same drivers then wore a customised pair of 'black-out' goggles, which simulated the degree of inattention that had been measured on previous laps. These 'black-out' goggles caused mayhem on the airfield and, by doing so, gave viewers a warning to keep their phones out of reach when on the road.

// Video streaming

Working with major international partners, BVI researchers have developed a technology that significantly improves video streaming quality. This technology, called ViSTRA (Video Spatio-Temporal Resolution Adaptation), has been integrated with state-of-the-art coding algorithms. It was awarded first prize in the IEEE ICIP international Video Compression Grand Challenge.

The example below shows how ViSTRA (left) performs better than state-of-the-art technology.

Video is everywhere – over 80% of all internet traffic is video. BVI researchers have produced world-leading video compression technologies.

NETFLIX, 'ELFUENTE'

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// Animal colours: adaptive for them, useful for us

IMAGE BY I. CUTHILL

"The colours of many animals seem adapted to their purposes of concealing themselves, either to avoid danger, or to spring upon their prey."

Erasmus Darwin, 1807: The Botanic Garden – A poem in two parts: part 1

This was written by Charles Darwin's grandfather, before Charles was even born. Animal coloration continues to be a fruitful testbed for theories of evolution, and can also inspire new technological developments.

Nature's rainbow

The vivid colours of a spring meadow and the mottled browns of a camouflaged moth may seem at opposite ends of Nature's rainbow. However, they are both adaptations to the eye and mind of another species. The meadow flowers use colour to compete for the attention of bees and other insect pollinators; the moth's camouflage serves to render it undetectable to a hungry bird. To understand the evolution of coloration, we must understand how animals see the world; in turn, colour patterns can help us understand vision and cognition in other species.

Nature and war

Concealment may be necessary against a foe with infra-red, ultra-violet or polarisation vision, with better resolution, more colour and faster processing than is possible for humans. Understanding evolution's responses to the problems of defeating detection and identification by such foes, and how a brain segments, recognises and tracks targets when those targets resemble the background, are core intellectual challenges for BVI biologists, psychologists and computer scientists. Military and animal coloration must also 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 conspicuousness) in both military and civilian contexts.

Creating colours

For a complete understanding of natural colours, knowing how they are produced is important. Nature doesn't only use pigments. Structures within body coverings (such as skin, hair, feathers and cuticle) 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. Physicists and engineers collaborate to address these questions. This integrated approach also sheds light on important applied questions, ranging from plant-pollinator ecology to the design of warning signage in urban environments.

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Human colour vision is just one of evolution's solutions to detecting and recognising objects.

Animal vision: seeing the world through different eyes

Animals see their world very differently from us

For example, birds can see ultra-violet light and 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. Such seemingly improbable visual abilities are common throughout the animal kingdom.

Information from light

Light varies not only in intensity and wavelength, but the way the waves travel: their polarisation. Indeed, octopus, squid and cuttlefish have dispensed with colour vision and use polarisation vision instead. Mantis shrimps use both. BVI biologists have discovered new ways animals use polarisation to improve visual contrast, use their eye movements to gain information and how animals use and create visual signals.

Liquid Crystal Display technology, developed by 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.

Industrial collaboration

New camera developments are being used to probe how animals see and to enhance our understanding of how animals interact with their world. 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.

Animal biometrics

Some animals use colour patterns to identify each other, but we can also use that information to identify them. BVI research is pioneering non-invasive approaches to monitoring and identification of individual animals using computer vision and biometric techniques.

Take the African penguin, an endangered species that has shown dramatic colony declines over the last 100 years. Traditionally, monitoring populations would involve putting numbered bands on the birds – stressful for them, stressful for the researcher – and then relying on resightings or recaptures. BVI researchers instead developed a system that used computer vision to identify individual penguins from their naturally varied plumage markings, all in real time from video. More recently, this concept of 'animal biometrics' has been used to help monitor other endangered species such as great apes and sharks.

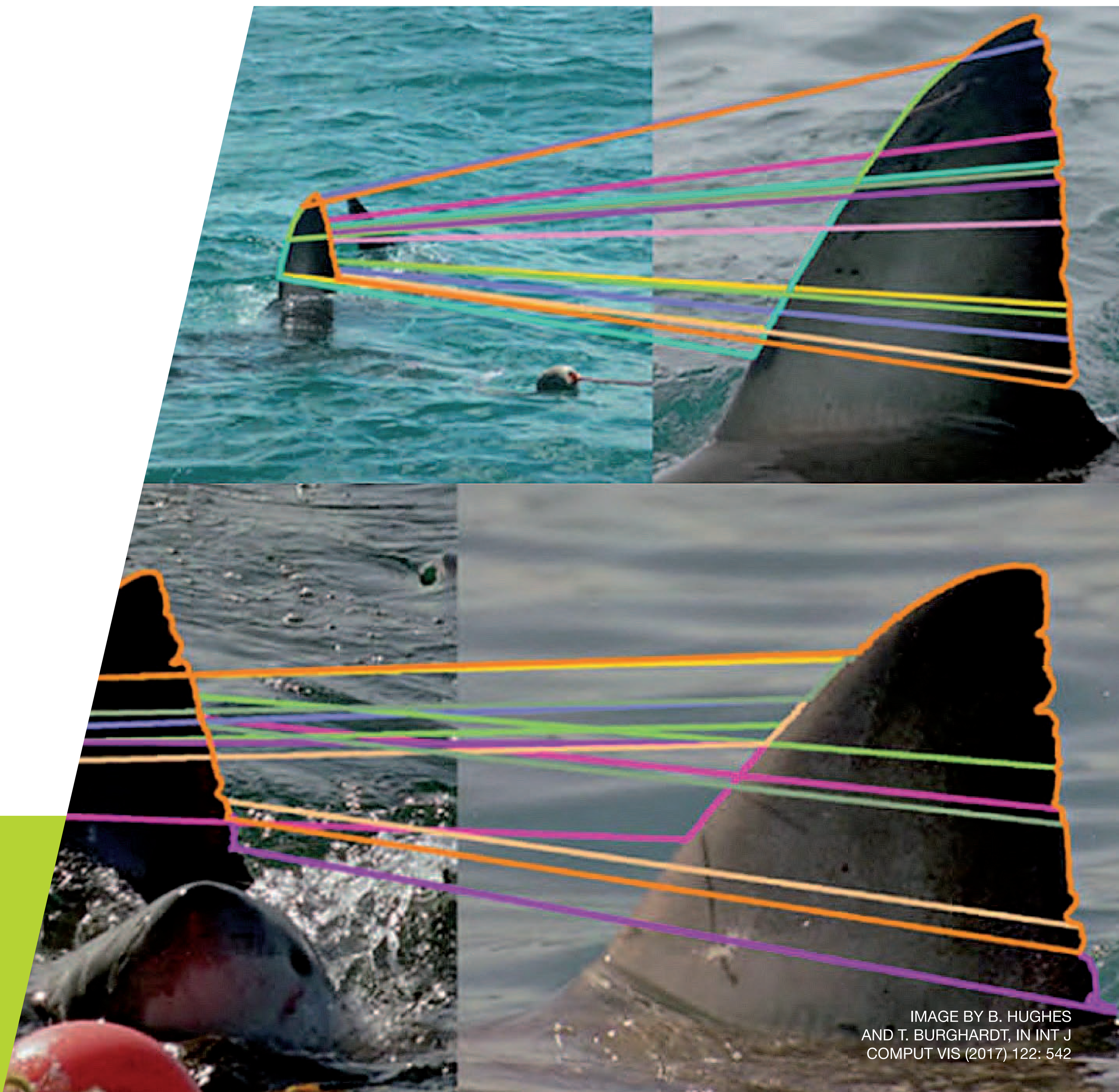

IMAGE BY B. HUGHES AND T. BURGHARDT, IN INT J COMPUT VIS (2017) 122: 542

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A healthy retina as seen at the back of the eye.

// Vision: eyes and brain working together through the lifespan

Sight is the result of our brain and eyes working together to gain information that allows us to interact with the world.

To "see" involves far more than reading down a vision chart or taking a quick snapshot of the world with our eyes. "Seeing" involves complex processes that our eyes and brains do for us, without us even knowing!

Many people are familiar with sight problems such as cataracts and age-related macular degeneration. These conditions are easily identified by looking at the eye and are treated every day in eye hospitals.

Cerebral visual impairments (CVIs)

Brain-related sight impairments, sometimes known as CVIs, however, are often not recognised and are not seen when looking into the eye. CVIs also reduce a person's ability to see, yet they too can be helped – either treated directly or compensated for. Examples in adults are loss of awareness of one side of visual field (hemianopia), which can happen after a stroke (a bleed in the brain); or difficulties in separating an object from its background, as can happen in dementia.

BVI research

BVI researchers are working on many aspects of how our brains let us see, from infancy to old age, including:

- What brain-related sight impairments affect children and/or adults
- How to best identify who has brain-related sight impairments at various stages of life
- How to best help people with brain-related sight impairments
- How to link in with other BVI scientists to help people of all ages with sight impairment
- Exploring the importance of visual environments
- Developing better signal processing and IT solutions
- Imaging and the use of artificial intelligence (AI) to provide "eyes" for visually impaired people in driverless cars.

The same retina seen in cross-section with ten layers of specialised nerve cells that connect directly with the brain, along the optic nerve.

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IMAGE BY U. LEONARDS AND J. FENNELL

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Impact of the visual environment

Do visual patterns on the floor influence the way we walk and where we walk? Do they make us veer or affect our ability to pass another person in the corridor without bumping into them?

BVI researchers from psychology, computer vision and engineering joined forces with architects, urban planners and artists to investigate how the visual make-up of built environments affects people's interactions with these environments and with each other, using the city as a living laboratory.

Such understanding is key when trying to create more inclusive, healthy and accessible environments for everybody. Follow #UrbanVisionScience to learn more about this area of research.

Follow your eyes

Humans move their eyes about three times a second – that's more eye movements than heartbeats in a day!

Unlike a camera, the human eye has a central area that is able to see fine detail – this region is called the fovea. The edges of vision are not able to resolve such detail.

In order to see things clearly, whether it's to read a book or cross a road, we need to move our eyes to point this high resolution fovea at objects or regions of interest. This is why we move our eyes so often. Sometimes the eyes move smoothly to track a moving object, such as a fly buzzing around your head and at other times they jump to move the eyes rapidly, for example when following a conversation between two people.

BVI researchers 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 provides fundamental knowledge about human vision, as well as enabling us to address more complex applied visual problems. BVI's eye tracking work has found applications in product placement, robotic guidance and in assessing visual immersion.

Recording eye movements to better understand visual behaviour in humans and animals.

IMAGE BY N.ROBERTS

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