Looking an eagle in the eye

THE NATURAL WORLD SHOWS THE WAY IN IMAGING TECHNOLOGY, WRITES **S ANANTHANARAYANAN**

The digital camera may be considered an accurate imitation of eyes. Electronic sensors take the place of the light-sensitive cells in the eye, and the electrical signals are put together to form the image, in the same way as the animal brain recreates an image from the sensations within the eyes.

Simon Thiele, Kathrin Arzenbacher, Timo Gissibl, Harald Giessen and Alois M Herkommer, from the research centre, SCoPE at the University of Stuttgart, have described in the journal, Science Advances, a method of going further, and creating in the lab the detail that helps animal eyes have increased clarity at a central point of gaze, placed within a wider, surrounding field of view.

The eagle is the most striking example of the way the animal eye has adapted to unparalleled functional sensitivity. The eagle has vision as good as 20/4, or the ability to see from 20 feet away what a human with normal eyesight can see at four feet. At four feet, most of us can see a grain of sand. The eagle can see this from twenty feet. And so it can see prey — the size of a field mouse — from a hundred metres away.

Eyes are not equally sensitive at all points in the field of view. The best resolution is right at the centre, a cone just two degrees wide, like the width of one's thumb at arm's length. This part of the image is formed at the centre of the retina, where there is a depression, the fovea, which has a great concentration of light sensitive cells. This region, about 1.5 mm wide, contributes nearly half the information load carried by the optic nerve and is packed with cones — the cells that are sensitive to colours and detail, rather than the rods, which are able to react in dim light.

The eagle has a more pronounced concentration of colour sensitive cells in the fovea and due to the narrow part of the field of view that is focussed at this region; the eagle can make out great detail, as if it were using a telephoto lens. The remaining part of the retina, however, is there to receive light from a wide field, so that the eagle can be warned of other birds or danger, even while it sees a selected, central region with the highest clarity, as if under a spotlight. The fovea of the eagle is even sensitive to the ultra violet and it can make out the urine trails of rodents and track them down.

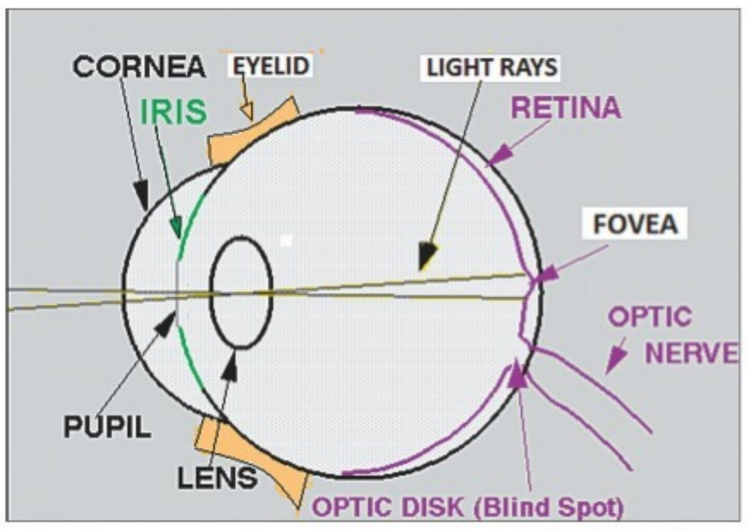
The digital camera creates images in much the same way as the animal eye. In place of the retina, the camera has an array of light-sensitive electronic units, which are rapidly scanned and the signal at each one of them is conveyed to the pixels of the display screen. The "perception" and the display are a series of digits that indicate if pixels in the display are illuminated or dark, and the distribution of pixels can be analysed with software. The broad similarity of the pattern of pixels in an image, to the patterns created by known objects, can thus be compared by computers and we have sensing arrangements that can recognise patterns or make out the letter in different kinds of writing and even recognise faces. The technology has advanced and we now have cameras, mounted on road vehicles, which are able to make out obstructions, even pedestrians on the road, thus driving of the vehicles can be automated.

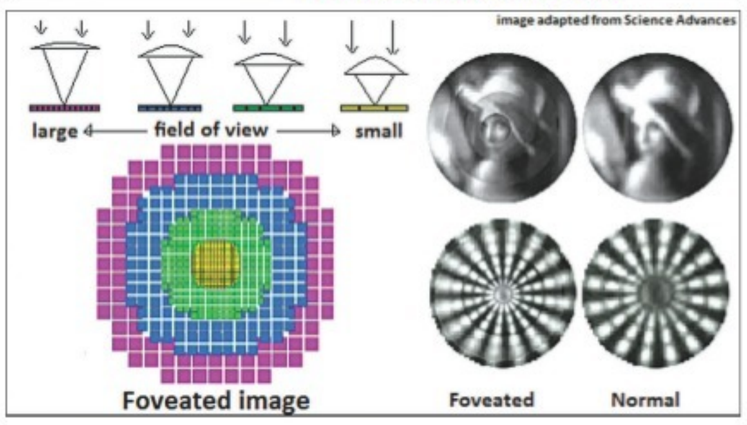
Thiele and others at the University of Stuttgart note that this and other applications call for the same concentration of detail in the central part of an image, like there is in the animal eye. The application of the "self-driven vehicle", for instance, would need to make out in detail, the objects that lie directly in its path, rather than objects in the periphery of the field of view. Providing greater clarity of the image in the centre of the field would lead to economising processor resources and optimising the efficiency of the arrangement.

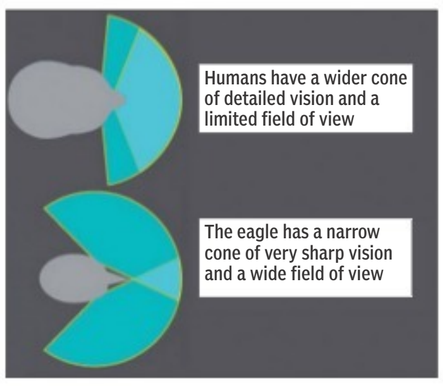
The electronic camera, unfortunately, works with light sensing units that are bulky, compared to the cells of the animal eye, and these do not allow the creation of a fovea,

with a greater population of sensors in one region. A development in electronic cameras, however, is the use of wafer-thin, multi-aperture arrays, where a great many micro-lenses generate a number of images, which can be combined using software. This arrangement, where information collected over a wide area contributes to the final image, makes for good resolution with less bulk and also avoids the distortion that comes with large lenses. The same arrangement, however, calls for intense processing power and cannot provide highest acuity of images with the rapidity that applications require.

The University of Stuttgart group observes that the current efficiency with which micro-lenses can be built, using methods of 3D printing, can help create an arrangement of lenses, which can form an image that is well-resolved in the central area and surrounded by a less well-resolved region. The way it is done is to use 3D printing to cover a light-sensitive electronic chip with an array of sets of four lenses each. The lenses form images of the same size on the chip, but the lenses are of differing focal lengths and the images have different dimensions. The first lens creates an image of a large field of view, the second of a lesser field, the third of lesser still and the fourth is a telephoto lens that creates a magnified image of the centre of the object being viewed. The different sets of four images are then merged, by software, and the final image is one with high resolution of detail







in the centre and reducing detail in concentric, larger circles.

Such a camera, guiding a self-driving vehicle, or for use with robots, drones or even in medical applications like endoscopes, would serve as an "eagle eye", providing clear vision at the centre of the field and still cover a larger, surrounding field, with less detail. The point of focus can be shifted and adjusted, with the background as the guide, to seek or follow a moving object.

The lenses are just a hundredth or a tenth of a millimetre across and the whole sensor is just a few square millimetres. "The computer that the device is connected to could have an IP address and the device could be controlled and viewed over the Internet, by a smart phone", says a press release put out by the University.

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PERFUME MATTERS A LOT

SCIENTISTS HAVE DISCOVERED THAT SCENT IS A KEY FACTOR WHEN IT COMES TO CHOICE OF MATES IN STICK INSECTS

An attractive scent is just as important as good looks when it comes to choosing a mate — at least among stick insect populations.

According to a new study, fragrance is an important factor in stick insects' choice of mate. It could explain why, when looks are deceiving, the insects are still able to show a preference for mates from the same species — a key to evolutionary success.

The findings, published in the journal, *Nature Ecology and Evolution*, are part of an 18-year research programme, in which scientists at the University of Sheffield and Royal Holloway, University of London, examined stick insect populations in California, US, to try to understand better what drives new species formation.

In evolutionary terms, the ability to avoid mixing genes with other species is important to preserve differences between species and evolve characteristics that are advantageous to survival. Natural selection plays a large part in this. For example, if an insect population has developed an effective camouflage that prevents birds from eating them, a new population of non-camouflaged individuals moving into the area might not last long, and so would be only a minor threat to the gene pool.

But scientists think that natural selection is not the whole picture — any survivors of predation could still mate, so what other factors might further promote speciation or the development of new and distinct species? The answer, at least for some groups of insects, appears to be largely down to the species' natural perfume.

The teams at Sheffield and Royal Holloway, studied more than 100 populations of stick insects, including 11 separate species, over nearly two decades, to try to find some answers to this evolutionary puzzle of how new species form.

"Species formation generally takes place over huge timescales and it's very difficult to observe directly — mainly we just get snapshots of what's happening at a particular moment in time," says Patrik Nosil, of the department of animal and plant sciences at the University of Sheffield. "What we've done is to take many snapshots and start to reconstruct the evolutionary process to build up a picture of what might be happening across these different populations and moments in time."

The researchers noticed that stick insects from different populations and species were unwilling to mate with each other. They discovered that mate choice appeared to be based on the mixture of particular chemical compounds on their skin that made them more or less attractive to each other. These oily chemicals protect the insects' bodies and prevent them from drying out but they also play an important role in "signalling" to attract suitable mates.

"We discovered that populations that differed most strongly in their chemical profiles discriminated more strongly against mating with one another, and they also differed more in their genomic sequences," explains Rudiger Riesch from the school of biological sciences at Royal Holloway, University of London.

The team also studied what happened when female stick insects were "perfumed" artificially with chemicals, either from their own, or from a different species — they found this directly affected how attractive they were to males. "We think these skin chemicals are the next step in speciation," says Nosil. "Even if the insects survive when placed into a different environment, the chemicals on their skin, provide the next barrier to them mixing their genes."

Even scent, however, is not a completely foolproof guarantee of species differentiation. Stick insects are still likely to occasionally mix and mate between populations even when they differ chemically.

"It takes a very long time to produce a new and entirely distinctive species. We think that natural selection and mate choice can cause substantial progress towards the formation of new species, but we still do not know what other factors help complete this process by preventing the insects from mixing their genes at all," adds Riesch.

Of crucial importance

FIBRONECTINS BIND CELLS TO THE EXTRA CELLULAR MATRIX AND GUIDE CELLULAR MOVEMENT, WRITES **TAPAN KUMAR MAITRA**

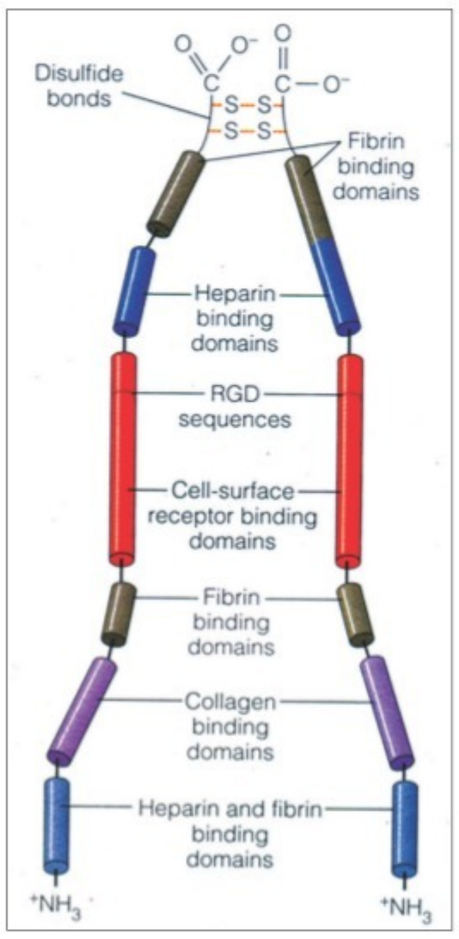
Fibronectins occur in soluble form in blood and other body fluids, as insoluble fibrils in the extracellular matrix, and as an intermediate form loosely associated with cell surfaces. The different forms of the protein are generated because the RNA transcribed from the fibronectin gene is processed in various ways to generate mRNAs that code for the several different proteins.

A fibronectin molecule consists of two very large polypeptide subunits that are linked near their carboxyl ends by a pair of di-sulfide bonds. Each subunit has about 2,500 amino acids and is folded into a series of rod-like domains connected by short, flexible segments of the polypeptide chain. Several of the domains recognise and bind to one or more specific kinds of macromolecules located in the ECM or on cell surfaces, including several types of collagen (I, II, and IV), heparin, and the blood-clotting protein fibrin. Other domains recognise and bind to cell-surface receptors. The receptor binding activity of these domains has been localised to a specific tripeptide sequence, RGD (arginine-glycine-aspartate). This RGD sequence is a common motif among extracellular adhesive proteins and is recognised by various integrins on the cell surface.

Fibronectin binds to cell-surface receptors as well as to ECM components such as collagen and heparin, and thus functions as a bridging molecule that attaches cells to the ECM. This anchoring role can be demonstrated experimentally by placing cells in a culture dish coated on the inside with fibronectin. Under these conditions, the cells attach to the surface of the dish more efficiently than they do in the absence of fibronectin. After attaching, the cells flatten out and components of the actin cytoskeleton become aligned with the fibronectin located outside the cell. Because the orientation and organisation of cyto-skeletal network are important in determining the shape of the cell, fibronectin is significant in the maintenance of cell shape.

Fibronectin is also involved in cellular movement. For example, when migratory embryonic cells are grown on fibronectin, they adhere readily to it. The pathways followed by migrating cells are rich in fibronectin, suggesting that such cells are guided by binding to fibronectin molecules along the way. Experimental support for this idea comes from studies in which developing amphibian embryos were injected with antibodies directed against fibronectin, thereby blocking the binding of cells to fibronectin. Normal cellular migration was disrupted, leading to the development of abnormal embryos.

More direct evidence for the importance of fibronectin in embryos comes from studying genetically engineered mice that cannot produce fibronectin. Such mice have severe defects in the cells that make the musculature along the length of the body and in the vasculature. These defects highlight the crucial importance of fibronectin during embryonic development.



A possible involvement of fibronectin in cancer is suggested by the observation that many kinds of cancer cells are unable to synthesise fibronectins, with an accompanying loss of normal cell shape and detachment from the ECM. If such cells are supplied with fibronectin, they often return to a more normal shape, recover their ability to bind to the ECM, and no longer appear malignant.

The soluble form of fibronectin present in the blood, called plasma fibronectin, is involved in blood clotting. Fibronectin promotes blood clotting because it has several binding domains that recognise fibrin, the blood-clotting protein, and it can attach blood platelets to fibrin as the blood clot forms.

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PLUS POINTS

A whole lot of 'planets'

The Earth's moon could be among more than 100 planets added to the solar system, according to leading scientists at Nasa.

Along with Titan and Enceladus, which orbit Saturn and Europa, and Ganymede, which orbits Jupiter, the moon has all the features of a planet. Alan Stern, principle investigator of Nasa's New Horizons mission to Pluto, along with five colleagues, has written a manifesto rewriting the definition of what constitutes being a planet.

One of the key changes is that they no longer need to be orbiting the sun to be considered planets, acco-rding to *The Times*. If the proposals are accepted by the International Astronomical Union, the current eight-planet solar system could see more than 100 added to it.

"In the mind of the public, the word 'planet' carries a significance lacking in other words used to describe planetary bodies… many members of the public assume that alleged 'non-planets' cease to be interesting enough to warrant scientific exploration," the team wrote in their manifesto.

The news comes as astronomers have discovered more than 100 new planets including one, which is thought to be a "super-earth" — a planet able to support life. A total of 114 new planets have been found, more than half of which are situated in our immediate solar neighbourhood. The so-called "super-earth" is in the fourth-closest star system to our sun and has been named Gilese 411b.

SHEHAB KHAN/THE INDEPENDENT

Zika after dengue

Even as the flurry surrounding the Zika virus dies down, a new concern has emerged in the scientific community studying the virus at the cellular level.

According to a paper published last December in the international scientific journal, *Clinical And Translational Immunology*, people who have developed immunity to dengue may develop a worse reaction to Zika, if they contract it later.

Zika and dengue are both flavi-viruses that are transmitted by Aedes aegypti mosquitoes.

US researchers studied cells of those who had contracted secondary dengue infections. Such an infection occurs when a patient contracts dengue, after having developed immunity from a first infection.

Their laboratory experiments showed that having a Zika infection after contracting dengue is worse compared with just having a Zika infection on its own.

SAMANTHA BOH/THE STRAITS TIMES

Super life forms

Ancient life forms that could be up to 50,000 years old have been found trapped inside crystals in tremendously hot Mexican caves, some as high as cathedrals.

The bizarre microbes were found dormant in Naica, Mexico, and were able to exist by living on minerals such as iron and manganese, said Penelope Boston, head of Nasa's Astrobiology Institute, which made the discovery.

"It's super life" she said as she presented the discovery at the American Association for the Advancement of Science conference in Boston. "It's simply another illustration of just how completely tough earth life is," she said. Boston, who revived the microbes both on the site and in a lab, said she is planning on doing more tests.

The findings are the results of nine years of work and have not yet been published in a scientific journal or been reviewed by peers.

The scientific team found there were 40 different strains of microbes and some viruses. Some are 10 per cent different genetically about as far as humans are from mushrooms, Boston said.

The Naica caves, in the northern state of Chihuahua in Mexico, are abandoned lead and zinc mines and are half a mile deep.

CHLOE FARAND/THE INDEPENDENT