There's more to implants than meets the eye

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In this month's *Physics World*, Richard Taylor, professor of physics, psychology and art at the University of Oregon, warns that artificial retinal implants – a technology fast becoming a reality – must adapt to the unique features of the human eye in order to become an effective treatment.

The gap between digital camera technology and the human eye is getting ever smaller, in terms of both the number of light-sensitive detectors and the space that they occupy. A human retina typically contains 127 million photoreceptors spread over an area of 1100 mm2. In comparison, today's state-of-the-art CMOS sensors feature 16.6 million photoreceptors over an area of 1600 mm2.

Despite the impressive progress of camera technology, several differences still remain, which is why, Taylor states, camera technology cannot simply be incorporated into the eye to restore the vision of patients with damaged rods and cones.

Taylor highlights that the eye tends to see what is directly in front of it – as the majority of its seven million cones are concentrated centrally – and less so on the periphery, whereas a camera captures everything in uniform detail with its pixels spread evenly across its entire field of view.

As such, the eye has to continually scan small areas to ensure that the image of interest falls mainly on the fovea – a pin-sized region positioned directly behind the lens that is crucial when visualizing detail.

This is because the human eye exploits fractal patterns – geometric shapes that are present throughout nature and repeat themselves down to the smallest scale. If the eye employed the uniform distribution of photoreceptors found in cameras, there would simply be too much information for the brain to process in real time.

Furthermore, Taylor states how certain natural fractal patterns such as clouds, trees and rivers are more aesthetically pleasing and can greatly reduce stress. This stress-reduction process would not occur with a camera-based implant as movement in the eye would become unnecessary, eventually leading to the eye learning not to move and therefore not activating the relevant areas of the brain to relieve stress.

As Taylor writes, "Remarkably, implants based purely on camera designs might allow blind people to see, but they might only see a world devoid of stress-reducing beauty. This flaw emphasizes the subtleties of the human visual system and the potential downfalls of adopting, rather than adapting, camera technology for eye."

In addition to the problem of photoreceptor distribution, Taylor also highlights the problem of connecting an implant's electrodes to retinal neurons, which are fractal in structure and tend to stay intact even if the eye's rods and cones themselves are damaged by disease. A solution to this, developed by Taylor and his colleagues, is nanocluster deposition.

This involves the delivery, through an inert gas, of nanoclusters of materials onto the photodiodes of an implant. These clusters then self-assemble into the required fractal shape and enhance the connection between retinal implants and healthy neurons while at the same time allowing light to pass through onto the photodiode.

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