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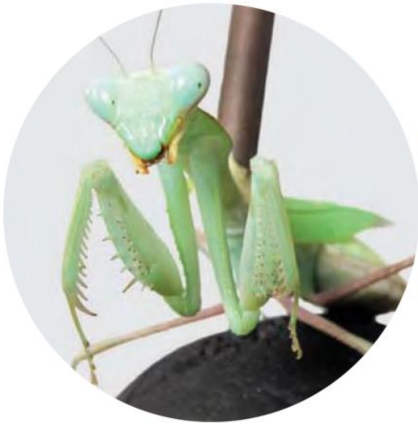
Man, mantis and machine: the computation of 3D vision



Research Leadership Award

Dr Jennifer Read, *Newcastle University*

3D movies such as *The Hobbit* exploit the brain's remarkable ability to deduce depth from the slightly different views seen by our eyes. In the cinema, of course, the different views require 3D glasses; in real life, they arise naturally because objects are at different distances. Modern 3D displays have many applications beyond entertainment. For example, displaying medical scans in 3D can make it easier to spot abnormalities.

3D vision is not limited to humans: animals as diverse as toads and horses can also see in 3D. Yet, due to the complexity of vertebrate brains, our understanding of the underlying neuronal processes remains poor. A simpler brain system became available for study in the 1980s with the revelation that an insect – the praying mantis – can also see in 3D.

The praying mantis is a miniature killing machine, seizing its prey with a lightning strike of its spiked forelegs. In the wild, the strike of a mantis is deadly accurate. But in the lab we can cause the mantis to strike when the prey is still out of range by placing prisms in front of its eyes. By bending light rays, prisms alter the usual relationship between the two eyes' images. The fact that mantids can be fooled in this way shows that they use 3D vision to guide their strike. With my Leverhulme Research Leadership Award, I aim to uncover how mantis 3D works, and shed new light on our own 3D abilities.

The relative simplicity of the insect system means that the circuitry can be traced much more easily: insect brains consist of only around a million neurons, compared to the billions in the mammalian brain. So it should be much easier to figure out how 3D works in an insect than in a monkey or a human. This is significant because, so far, 3D vision has turned out to be remarkably similar across systems. For example, owls see in 3D much as we do, even though their 3D vision evolved independently. Furthermore, computer scientists have independently come up with almost identical techniques for robot 3D vision.

All these different 3D systems can spot camouflaged objects. Even if an object blends in perfectly with its background when seen with one eye, 3D vision reveals how its shape stands out from the background. This was one of the earliest technological applications of 3D, in aerial reconnaissance during the First World War, and is thought to be a key reason why 3D vision evolved.

However, many scientists argue that human-like 3D vision is too complex for an insect. They argue that mantis 3D can only estimate distances to objects which are already visible, but cannot reveal objects which are camouflaged. If this is correct, then understanding mantis vision could inspire new, simpler forms of machine 3D vision. These could help us implement effective 3D vision in small autonomous robots, where weight and power restrictions rule out conventional solutions. Conversely, if insect 3D turns out to be similar to that in robots, owls, monkeys and humans, then understanding 3D in the simple insect system may be a fast-track towards understanding it in the far more complex human brain. Whatever the answer, the praying mantis has a lot to teach us.

ABOVE: Mantis in our lab. Note the huge compound eyes and the vicious raptorial forelegs!

LEFT: Mantis in the wild, camouflaged in its rich visual environment. Wikimedia Commons. *Courtesy of Maryland Pride.*