Nature Offers Better Vision System For Smart Weapons

The next generation of smart weapons may "see" targets with a man-made version of that wonder of the natural world, the insect eye.

Inspired by the panoramic and precise vision of flies and other insects, researchers at several universities and institutions are working on biologically inspired "eyes" for smart weapons and other self-guided machines. At the University of Florida, the focus of the "bio-optics synthetic systems research," sponsored by the federal Defense Advanced Research Projects Agency, or DARPA, is on adapting mechanisms called "photon sieves" for visual purposes.

"We think we can use this concept to make smart weapons smarter," said Paul Holloway, a distinguished professor of materials science and engineering and the project's lead researcher.

Holloway and several colleagues at UF have received more than $400,000 for the first phase of the research from DARPA. The project is only about a year old, but the researchers have applied for several patents for their findings and plan scientific publication of their work.

Holloway said today's smart weapons rely on systems that use refractive optics, or lenses that bend light, to produce a focused view of the target. The resulting image is like what is seen through a telescope — the view of the target is good but the surroundings are completely lost. This limits a weapon's accuracy on moving targets, as well as its ability to overcome flares or other counter measures designed to confuse the weapon.

Refractive systems also are relatively heavy because they use mechanical systems to move the lens and keep the target in view. The added weight requires more propellant and increased size, which boosts the cost, Holloway said.

The alternative approach of Holloway's team of engineers and physicists relies on diffractive optics, which uses interference effects to redirect light in different directions rather than bending it. Their vision for the technology merges the developments of a 19th-century French physicist named Augustin Fresnel with a modern appreciation of how insect eyes work.

Fresnel invented the Fresnel zone plate, also known as the Fresnel lens,

which uses concentric circles of transparent and opaque material to diffract light into a single, marginally focused beam. The Fresnel lens became the standard on lighthouses for many years. Holloway and his colleagues have modified the zone plate, replacing the transparent rings with a series of precisely spaced holes that sharpen the focus quality of the beam. Although similar devices, called photon sieves, had been developed before, they are typically used for X-rays or other electromagnetic radiation outside the visible light spectrum.

The UF team is the first to develop photon sieves for visible and longer-wavelength light, including infrared light, Holloway said. The latter can have important implications for weaponized vision systems, which sometimes use infrared light.

The team has made and tested small prototypes of the lenses. Once perfected, the next step could be to put many such lenses together — some designed for high resolution, others for lower resolution — onto a surface to produce a multiple-eye effect, Holloway said. The result would be a lightweight panoramic vision device with no moving parts, he said.

Leonard J. Buckley, a program manager in materials chemistry at DARPA's Defense Science Office, said the technology is promising.

"This technology has the potential to change the way we think about optics and specifically about optical lenses," he said. "Inspiration from nature has enabled the pursuit of new materials approaches to optical components, which will allow more life-like qualities in the system."

Smart weapons aren't the only potential application. Robots designed to operate autonomously, such as those used to transport nuclear materials, fight oil well fires or do other tasks too dangerous for people, also could benefit from improved vision systems, he said. Eventually, such lenses may even replace refractive lenses in consumer products, such as cameras, making them lighter and potentially reducing their costs.

Other researchers working on the UF project include David Tanner, a UF distinguished professor of physics; Mark Davidson, a UF research scientist; and Gary McGuire, Olga Shenderova and Alex Shenderov, researchers at the International Technology Center in North Carolina's Research Triangle Park.

Paul Holloway, pholl@mse.ufl.edu

Aaron Hoover