Engineers to use cyborg insects as biorobotic sensing machines

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Researchers at Washington University in St. Louis are using a locust's sense of smell to develop new biorobotic sensing devices. Credit: Washington University in St. Louis

A team of engineers from Washington University in St. Louis is looking to capitalize on the sense of smell in locusts to create new biorobotic sensing systems that could be used in homeland security applications.

Baranidharan Raman, associate professor of biomedical engineering in the School of Engineering & Applied Science, has received a three-year, $750,000 grant from the Office of Naval Research (ONR) to use the highly sensitive locust olfactory system as the basis to develop a bio-hybrid nose. Joining Raman in the research are engineering colleagues Srikanth Singamaneni, associate professor of materials science, and Shantanu Chakrabartty, professor of computer science & engineering.

Biological sensing systems are far more complex than their engineered counterparts, including the chemical sensing system responsible for our sense of smell, Raman said. Although the sense of smell is a primitive sense, it is conserved across many vertebrate and invertebrate species.

"It appears that biology converged onto a solution for the problem of non-invasive, or 'standoff' chemical sensing and has replicated the same design and computing principles everywhere," Raman said. "Therefore, understanding the fundamental olfactory processing principle is necessary to engineer solutions inspired by biology."

For several years and with prior funding from the ONR, Raman has been studying how sensory signals are received and processed in relatively simple brains of locusts. He and his team have found that odors prompt dynamic neural activity in the brain that allow the locust to correctly identify a particular odor, even with other odors present. In other research, his team also has found that locusts trained to recognize certain odors can do so even when the trained odor was presented in complex situations, such as overlapping with other scents or in different background conditions.

"Why reinvent the wheel? Why not take advantage of the biological solution?" Raman said. "That is the philosophy here. Even the state-of-the-art miniaturized chemical sensing devices have a handful of sensors. On the other hand, if you look at the insect antenna, where their chemical sensors are located, there are several hundreds of thousands of sensors and of a variety of types."

The team intends to monitor neural activity from the insect brain while they are freely moving and exploring and decode the odorants present in their environment.

Such an approach will also require low power electronic components to collect, log and transmit data. Chakrabartty, an expert in developing miniature electronics in his Adaptive Integrated Microsystems Laboratory, will collaborate with Raman to develop this component of the work.

The team also plans to use locusts as a biorobotic system to collect samples using remote control. Singamaneni, an expert in multifunctional nanomaterials, will develop a plasmonic "tattoo" made of a biocompatible silk to apply to the locusts' wings that will generate mild heat and help to steer locusts to move toward particular locations by remote control. In addition, the tattoos, studded with plasmonic nanostructures, also can collect samples of volatile organic compounds in their proximity, which would allow the researchers to conduct secondary analysis of the chemical makeup of the compounds using more conventional methods.

"The canine olfactory system still remains the state-of-the-art sensing system for many engineering applications, including homeland security and medical diagnosis," Raman said. "However, the difficulty and the time necessary to train and condition these animals, combined with lack of robust decoding procedures to extract the relevant chemical sending information from the biological systems, pose a significant challenge for wider application.

"We expect this work to develop and demonstrate a proof-of-concept, hybrid locust-based, chemical-sensing approach for explosive detection."

Provided by Washington University in St. Louis