Researchers develop ultrasensitive vibration monitors based on spider organs

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Female comb-footed spider (family Theridiidae), Enoplognatha ovata. Photographed in the wild at DuPage County, Illinois, USA. Size = 15mm. Credit: Bruce Marlin/Wikipedia/CC BY 3.0

A team of researchers in South Korea has created an ultrasensitive vibration monitor that is based on the lyriform organ in wandering spider legs. In their paper published in the journal *Nature*, the team describes the lyriform organ, how it works and how they applied what they learned to a new monitor that could have applications in music, speech recognition and health monitoring. Peter Frazel of the Max Planck Institute explains the work in more detail in a News & Views piece in the same journal issue.

The male wandering spider attempts to seduce the female by scratching leaves with its belly—the female is able to pick up these minute vibrations due to the lyriform organ in it legs—essentially parallel slits that when disturbed can set off nerves that are converted to something that makes sense in the spider brain. In this new effort, the researchers reproduced the organ in their lab.

The team built their sensor by applying a 20 nanometer layer of platinum on top of a soft polymer and then introduced a series of parallel cracks. Because the layer is on top of a somewhat elastic base, the device can be stretched slightly, which happens when vibration is introduced. Sending electricity across the top layer allows for the device to be used as a vibration sensor because the distance across the individual cracks varies when the device is placed on a surface where vibration is present, which causes changes to how much electricity can pass. To sense vibration, all the team had to do was measure the sensor's resistance.

Such a sensor potentially has a lot of applications. As one example, the researchers placed it on a violin and used it to identify notes being played. They also placed the device on the necks of several volunteers and found that it was capable of being used to recognize words being spoken by them. The team believes the sensor could be used to monitor health too, noting that placing it on the wrist allowed for monitoring heartbeat—in a package so small it would be nearly unnoticeable. They found that it could also be useful when placed in liquids, as a means of testing pressure differences, which could be applied in medical applications.

More information: Ultrasensitive mechanical crack-based sensor inspired by the spider sensory system, *Nature* 516, 222–226 (11 December 2014) DOI: 10.1038/nature14002

Abstract
Recently developed flexible mechanosensors based on inorganic silicon, organic semiconductors, carbon nanotubes, graphene platelets, pressure-sensitive rubber and self-powered devices are highly sensitive and can be applied to human skin. However, the development of a multifunctional sensor satisfying the requirements of ultrahigh mechanosensitivity, flexibility and durability remains a challenge. In nature, spiders sense extremely small variations in mechanical stress using crack-shaped slit organs near their leg joints12. Here we demonstrate that sensors based on nanoscale crack junctions and inspired by the geometry of a spider's slit organ can attain ultrahigh sensitivity and serve multiple purposes. The sensors are sensitive to strain (with a gauge factor of over 2,000 in the 0–2 per cent strain range) and vibration (with the ability to detect amplitudes of approximately 10 nanometres). The device is reversible, reproducible, durable and mechanically flexible, and can thus be easily mounted on human skin as an electronic multipixel array. The ultrahigh mechanosensitivity is attributed to the disconnection–reconnection process undergone by the zip-like nanoscale crack junctions under strain or vibration. The proposed theoretical model is consistent with experimental data that we report here. We also demonstrate that sensors based on nanoscale crack junctions are applicable to highly selective speech pattern recognition and the detection of physiological signals. The nanoscale crack junction-based sensory system could be useful in diverse applications requiring ultrahigh displacement sensitivity.