New wearable communication system offers potential to reduce digital health divide

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Wearable devices that use sensors to monitor biological signals can play an important role in health care. These devices provide valuable information that allows providers to predict, diagnose and treat a variety of conditions while improving access to care and reducing costs.

However, wearables currently require significant infrastructure—such as satellites or arrays of antennas that use cell signals—to transmit data, making many of those devices inaccessible to rural and under-resourced communities.

A group of University of Arizona researchers has set out to change that with a wearable monitoring device system that can send health data up to 15 miles—much farther than Wi-Fi or Bluetooth systems can—without any significant infrastructure. Their device, they hope, will help make digital health access more equitable.

The researchers introduce novel engineering concepts that make their system possible in the journal *Proceedings of the National Academy of Sciences.*

Philipp Gutruf, an assistant professor of biomedical engineering and Craig M. Berge Faculty Fellow in the College of Engineering, directed the study in the Gutruf Lab. Co-lead authors are Tucker Stuart, a UArizona biomedical engineering doctoral alumnus, and Max Farley, an undergraduate student studying biomedical engineering.

Designed for ease, function and future

The COVID-19 pandemic, and the strain it placed on the global health care system, brought attention to the need for accurate, fast and robust remote patient monitoring, Gutruf said. Non-invasive wearable devices currently use the internet to connect clinicians to patient data for aggregation and investigation.

"These internet-based communication protocols are effective and well-developed, but they require cell coverage or internet connectivity and main-line power sources," said Gutruf, who is also a member of the UArizona BIO5 Institute. "These requirements often leave individuals in remote or resource-constrained environments underserved."

In contrast, the system the Gutruf Lab developed uses a low power wide area network, or LPWAN, that offers 2,400 times the distance of Wi-Fi and 533 times that of Bluetooth. The new system uses LoRa, a patented type of LPWAN technology.

"The choice of LoRa helped address previous limitations associated with power and electromagnetic constraints," Stuart said.

Alongside the implementation of this protocol, the lab developed circuitry and an antenna, which, in usual LoRa-enabled devices, is a large box that seamlessly integrates into the soft wearable. These electromagnetic, electronic and mechanical features enable it to send data to the receiver over a long distance.

To make the device almost imperceptible to the wearer, the lab also enables recharge of its batteries over two meters of distance. The soft electronics, and the device's ability to harvest power, are the keys to the performance of this first-of-its-kind monitoring system, Gutruf said.

The Gutruf Lab calls the soft mesh wearable biosymbiotic, meaning it is custom 3D-printed to fit the user and is so unobtrusive it almost begins to feel like part of their body. The device, worn on the low forearm, stays in place even during exercise, ensuring high-quality data collection, Gutruf said. The user wears the device at all times, and it charges without removal or effort.

"Our device allows for continuous operation over weeks due to its wireless power transfer feature for interaction-free recharging—all realized within a small package that even includes onboard computation of health metrics," Farley said.

Gutruf, Farley and Stuart plan to further improve and extend communication distances with the implementation of LoRa wireless area network gateways that could serve hundreds of square miles and hundreds of device users, using only a small number of connection points.

The wearable device and its communication system have the potential to aid remote monitoring in underserved rural communities, ensure high-fidelity recording in war zones, and monitor health in bustling cities, said Gutruf, whose long-term goal is to make the technology available to the communities with the most need.

"This effort is not just a scientific endeavor," he said. "It's a step toward making digital medicine more accessible, irrespective of geographical and resource constraints."

More information: Biosymbiotic platform for chronic long-range monitoring of biosignals in limited resource settings, *Proceedings of the National Academy of Sciences* (2023). DOI: 10.1073/pnas.2307952120. doi.org/10.1073/pnas.2307952120

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