New upgrades to old wireless tech could enable real-time 3D motion capture

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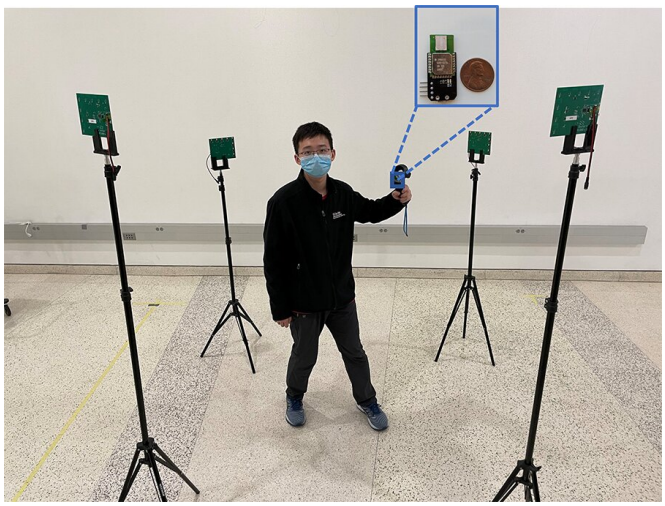

The new UWB system consists of a small electronic tag (inset shows the size of a tag compared to a U.S. penny) that transmits one signal simultaneously to four anchors. Credit: University of California - San Diego

A wireless technology that is helping people find their keys and wallets could one day be used for precise and real-time 3D motion capture, thanks to upgrades developed by electrical engineers at the University of California San Diego.

The team's new work improves on a wireless communication technology called ultra-wideband, or UWB. The technology has been around for years, but only recently has UWB started gaining popularity as it promises greater accuracy than Wi-Fi and Bluetooth for determining the location and movement of other devices.

It also has the potential to open up even bigger possibilities, such as indoor navigation; smart warehouses that provide precise and real-time location of inventory and personnel; and 3D motion capture that can be done wirelessly in real-time for applications such as VR and sports analytics.

But to get there, several limitations of current UWB technology must be overcome, said Dinesh Bharadia, a professor of electrical and computer engineering and faculty member of the Center for Wireless Communications at the UC San Diego Jacobs School of Engineering. UWB systems need to work much faster than they do now, operate at extremely low power, and provide high accuracy in 3D localization, he explained.

Bharadia's Wireless Communication Sensing and Networking group recently developed a prototype UWB system that meets these criteria. It communicates data with a latency of just one millisecond; it uses so little power that it can run continuously for more than two years on a small coin cell battery; and it can pinpoint 3D location to within three centimeters for stationary objects, and eight centimeters for moving objects.

The researchers will present their UWB system, dubbed ULoc, at the UbiComp 2021 conference which will take place virtually from Sept. 21 to 26.

The new system fundamentally changes the process that UWB systems use to locate an object. UWB systems typically consist of two main components: a small tracking device called a tag, which can be attached to an object, and a set of devices called anchors that are installed at various spots in the environment to detect radio signals from the tag.

The way UWB tracking currently works is that the tag sends out signals to all the anchors, and the anchors in turn send these signals back to the tag. The system measures the times that it takes for these signals to return to the tag. It then uses this information to calculate the distances between the tag and each anchor, and the tag's location can then be triangulated.

The problem with this process, explained Bharadia, is that it involves a lot of signal exchanges. One tag

needs to send a separate signal to every anchor, and every anchor, in turn, sends a signal back to the tag. "This makes the system slow. It's not scalable, and it does not provide 3D localization," said Bharadia.

To simplify this process, the researchers updated the software for the tag so that it only needs to send one signal total to all the anchors. This also drastically reduces the tag's power use; it can run continuously for more than two years on a small coin cell battery, while current UWB tags can only last for a few months on this type of battery. They also built new anchors that can work with just that one signal and get a good read of the tag's 3D location. The team developed special antenna arrays and new algorithms that enable the anchors to accurately estimate the 3D angle and direction from which the tag's signal is arriving. The anchors are able to measure this 3D angle from multiple vantage points so they can locate the tag with precision.

In tests, the new UWB system accurately tracked the 3D location of the tag within a millisecond of latency while one of the researchers was holding it and moving it around an open office space. The researchers point out that the system performed well despite it being in a "noisy" environment—computer screens, glass windows, and metal sheets interfere with UWB signals and create noise.

The team is now working on building an end-to-end motion capture system for applications ranging from VR gaming to sports analytics and autonomous robots for healthcare. The researchers say they are looking to collaborate with industrial partners to further develop and commercialize the technology.

More information: Minghui Zhao et al, ULoc, *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies* (2021). DOI: 10.1145/3478124

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