Berkeley team explores sound for indoor localization

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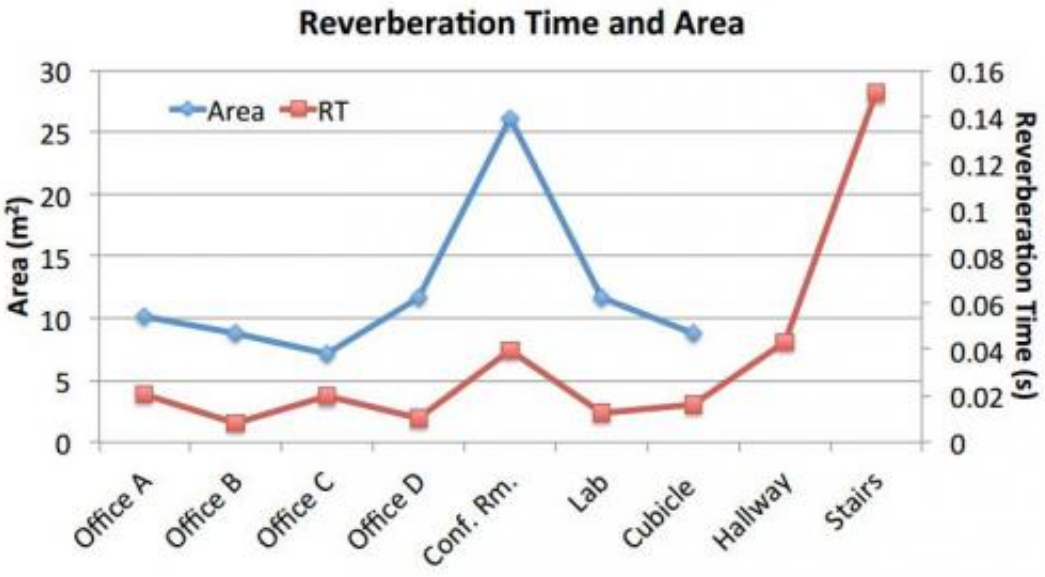

Credit: arXiv:1407.4409 [cs.HC]

The global positioning system, or GPS, has its limitations—namely, it cannot work indoors. Potential solutions for indoor positioning continue to fire up the imaginations of scientists. The latest news involves a form of echolocation. MIT Technology Review reported on the approach for indoor localization based on sound. Ruoxi Jia and team at the University of California, Berkeley developed a simple, cheap mechanism, said Technology Review, that can identify rooms based on a relatively small dataset. Their paper describing their system was submitted on July 16 to the arXiv server; authors are Ruoxi Jia, Ming Jin, and Costas J. Spanos

of the University of California, Berkeley. They call their system SoundLoc. In their paper, "SoundLoc: Acoustic Method for Indoor Localization without Infrastructure," they described SoundLoc as "a room-level localization system that exploits the intrinsic acoustic properties of individual rooms." Their SoundLoc method is based on the extraction of acoustic features of rooms. The team said they can acquire RIRs [room impulse responses]by using built-in speakers and microphones on laptops.

Also, a "noise adaptive reverberation extraction algorithm" was developed for feature extraction from the noisy RIRs. How it works: "Emit a sound and then listen for the return which will be distorted in a way that depends on the size and shape of the room, the materials on the walls and floors as well as the furniture and people within it," said Technology Review.

The researchers tested their system in ten rooms on the Berkeley campus. Data was taken using the built-in microphone and speakers on an ordinary laptop. "The laptop produces a set of sound waves and then listens for the echo. They took 50 samples at each location, which included background noise such as footsteps, talking and heating and ventilation sounds. They processed this data to find the echo fingerprint for each room," said Technology Review. -

The team said there was a 97.8 percent accuracy in identifying the individual rooms. They wrote, "The acoustic features we extracted are shown to be distinctive, robust and efficient to compute. 97.8% of overall accuracy has been achieved for 10 rooms' identification."

Of what use is their research? MIT Technology Review commented how "Jia and co are particularly interested in using the technique to reduce the energy consumption in buildings. Some 40% of energy usage in the US comes from commercial and residential buildings. If those buildings

are empty, then that represents a significant waste."

The authors said in their paper that "Identifying locations of occupants is beneficial to energy management in buildings. A key observation in indoor environment is that distinct functional areas are typically controlled by separate HVAC and lighting systems and room level localization is sufficient to provide a powerful tool for energy usage reduction by occupancy-based actuation of the building facilities."

More information: SoundLoc: Acoustic Method for Indoor Localization without Infrastructure, arXiv:1407.4409 [cs.HC] arxiv.org/abs/1407.4409

Abstract

Identifying locations of occupants is beneficial to energy management in buildings. A key observation in indoor environment is that distinct functional areas are typically controlled by separate HVAC and lighting systems and room level localization is sufficient to provide a powerful tool for energy usage reduction by occupancy-based actuation of the building facilities. Based upon this observation, this paper focuses on identifying the room where a person or a mobile device is physically present. Existing room localization methods, however, require special infrastructure to annotate rooms.

SoundLoc is a room-level localization system that exploits the intrinsic acoustic properties of individual rooms and obviates the needs for infrastructures. As we show in the study, rooms' acoustic properties can be characterized by Room Impulse Response (RIR). Nevertheless, obtaining precise RIRs is a time-consuming and expensive process. The main contributions of our work are the following. First, a cost-effective RIR measurement system is implemented and the Noise Adaptive Extraction of Reverberation (NAER) algorithm is developed to estimate room acoustic parameters in noisy conditions. Second, a comprehensive physical and statistical analysis of features extracted from RIRs is

performed. Also, SoundLoc is evaluated using the dataset consisting of ten (10) different rooms. The overall accuracy of 97.8% achieved demonstrates the potential to be integrated into automatic mapping of building space.