Deep-learning system detects human presence by harvesting RF signals

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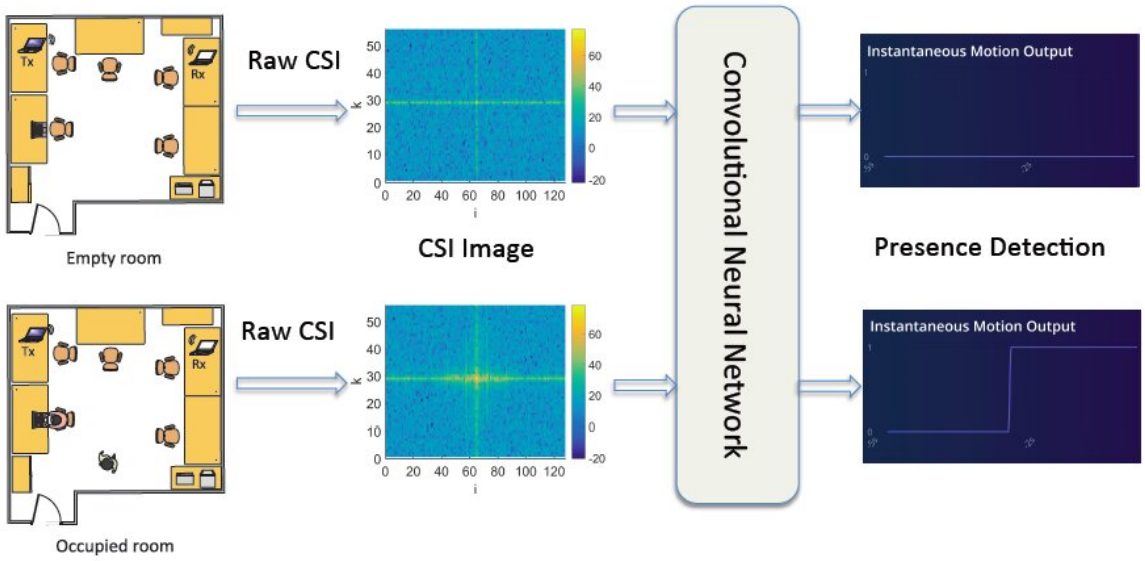

Figure explaining how the deep learning-based, RF sensing system developed by the researchers works. Credit: Liu et al.

Researchers at Syracuse University in New York have recently developed a system that can detect the presence of humans in a given environment by analyzing ambient radio frequency (RF) signals. This new system, presented in a paper pre-published on arXiv, employs a convolutional neural network (CNN) trained on a vast amount of RF data.

"Initially, we tried to detect drones in an outdoor environment using passive RF signals through deep learning," Biao Chen, one of the researchers who carried out the study, told TechXplore. "The result was uneven at best—it worked on measurements collected on certain days, but would fail on other days."

For some time, Chen and his colleagues tried to develop a system that could sense the presence of drones in outdoor environments. However, they soon realized that consistently detecting drones by analyzing passive RF signals was almost impossible, as they had no control over the environments it was moving in. Their system was designed to extract RF signatures induced by the drone's movements as it alters the propagation channels, yet it was also affected by passing cars, people walking their dogs, and anything else that moved in the surrounding environment.

"In the drone experiment, we were never able to achieve consistent results," Chen explained. "The learning system we developed, however, can be easily adapted to indoor applications where the environment is much easier to control and calibrate. This eventually led us to develop a deep learning-based presence detection system using ambient WiFi signals."

The presence of humans in a room or in other indoor environments can alter the propagation of RF signals in several ways. By pre-processing RF channel measurements, the researchers were able to create 'images' summarizing the signals, which could in turn be analyzed to detect the presence of humans in a given environment.

They then trained a CNN on a large amount of data containing both magnitude and phase information, two key properties of RF signals. Over time, the deep learning algorithm learned to distinguish when an environment is populated by humans and when it is free from them by analyzing what is known as channel state information (CSI).

"Exploiting the ubiquity of ambient RF signals such as WiFi, Bluetooth or cellular signals for situational awareness information provides added value to existing RF infrastructure," Chen said. "Occupancy detection, for example, is an application where RF sensing can be a low-cost and infrastructure-free alternative or complement to existing approaches."

Chen and his colleagues evaluated their CNN-based system in a number of experiments conducted inside their lab, using off-the-shelf WiFi devices. Their system was found to reliably detect human presence in almost all cases, outperforming several state-of-the-art passive infrared sensors.

In the future, the system developed by this team of researchers could have a number of useful applications. For instance, it could be used to detect the presence of humans in a restricted or private area. Attaining data related to occupancy and human presence in real-time could also help to improve building intelligence and reduce energy consumption (e.g., for HVAC and lighting control).

"Deep learning is often touted for being data-driven," Chen said. "The flip side is the demand on training data (both in quantity and in quality) can be overwhelming. For the technology to truly become practical, the end user should not be burdened with data collection and training. Thus, our current and future work will attempt to achieve reliable presence detection without the need to collect motion data."

This is a website created by the researchers that monitors human presence in their lab 24/7: demo.wifisensing.com/

More information: Harvesting ambient RF for presence detection through deep learning. arXiv:2002.05770 [cs.LG]. arxiv.org/abs/2002.05770