Sensing human presence in a room using dynamic metasurface antennas

Unmet Need

The current primary method for detecting the presence of humans inside of a building or room is the use of motion detectors that rely on radio frequency or infrared light. The global market for smart home security monitoring sensors is currently valued at approximately $2 billion – the cost of one system typically starts at about $500 but can range from $200 to over $2,000. While these are generally reliable systems, they require a line-of-site path between the human and the detector and require the person to be in motion. More sophisticated technologies have been developed to mitigate these limitations, but they are often drastically more complex and expensive. There is a need for affordable sensors that can detect human presence with high fidelity and without the need for a direct line-of-sight path.

Technology

Duke inventors have developed a sensor for detecting humans in a room or building. This is intended to be used to detect intruders in secure environments (homes, data centers, etc.). Specifically, this technology utilizes one or several dynamic metasurface antennas (DMAs) as transmitters and/or receivers to probe the electromagnetic waveforms that are scattered directly and indirectly off a human inside of the room or building. DMAs consist of a waveguide or cavity with subwavelength metamaterial elements patterned into the structure. A radio frequency (RF) source injects a signal into the waveguide or cavity and the signal is leaked out by the metamaterial elements. The statistical variation in the scattering events detected by the receiver as a person enters or moves within a room is used to detect their presence. Importantly, by incorporating switchable components into the metamaterial elements and tuning them independently, DMA patterns can be altered with the electronic circuitry without the need for complex or expensive hardware. This sensor has been demonstrated to operate at millimeter wave frequency range and eliminates the need for direct line-of-site paths, meaning that all locations in a space can be probed (i.e. through solid objects such as thin walls or furniture). There is currently a working model of this sensor that has been tested extensively in staged cluttered rooms. Planned future steps for this project will focus on testing variations in placement/orientation of the transmitter and receiver and analysis method development, including advanced signal processing techniques and/or machine learning algorithms.

Other Applications

This technology could also be used as an occupancy sensor in common residential buildings to control temperature settings, which could reduce energy waste of residential buildings. It could also be used for monitoring vital signs of life in elderly patients or infants without intrusive hardware, like cameras.

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Meet the Inventors

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Publication(s)

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External Link(s)

• From the lab of Dr. Seyedmohammadreza Faghih Imani
• From the lab of Dr. David Smith
• Dynamic Metasurface Antennas for Detecting Human Presence (ARPA - Energy, 2017)
• Electronically steered metasurface antenna (Scientific Reports, 2021)

Advantages

- Utilizes simple, low-cost semiconductor and RF components
- Sensor can scan entire space, including through non-metallic objects (furniture, walls); i.e. no direct line-of-sight requirement
- Sensor is physically small
- Sensor has a large operating range and fast acquisition rate with high sensitivity
- Low concern over interference with other devices
- No harmful effects to humans or animals