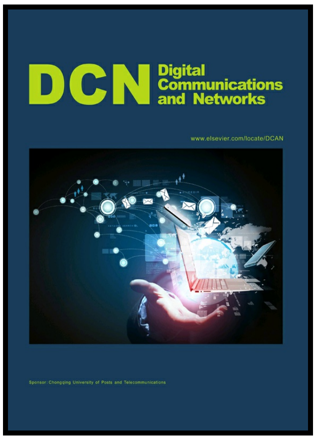

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Experimental Approach for Seeing Through Walls Using Wi-Fi Enabled Software Defined Radio Technology

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Abstract

Modern handheld target detection methods are typically restricted to line of sight (LOS) techniques. Design of a new method to detect moving targets through non-transparent surfaces could greatly aid in the safety of hazardous military and government operations. In this paper, we develop through-wall virtual imaging using Wi-Fi enabled software defined radio to see moving objects and their relative locations. We use LabVIEW and NI Universal Software Radio Peripheral (NI USRP2921 radios with Ettus Research LP0965 directive antennas) devices to detect moving objects behind walls by sending and receiving a signal with respect to the USRP's location. Based on the signal-to-interference ratio of our signal (rather than the traditional signal-to-noise method), we determine the target object behind the wall. The two major applications for this project are: detecting an active shooter that is standing on the other side of the wall and detecting abnormalities in the human body such as breast cancer with more sensitive antennas. Likewise, firefighters, law enforcement, and military would find more practical purposes for the use of this system in their fields. We evaluate the proposed model using experimental results.

Keywords: Wi-Fi based imaging, Throughwall, imaging, Software defined radio

Inroduction

The design of an easily moveable radar detection system would allow for military and government operations to decrease the amount of money allocated to large equipment and also allow for on-the-go operations in highly dangerous areas. Through wall imaging is a relatively new topic in engineering that uses wireless technology for imaging. In this paper, we develop a prototype system that uses a Wi-Fi enabled National Instrument USRP device with a directional antenna and LabVIEW in order to track or see moving objects/people through walls. First we design a Virtual Instrument (VI) which can transmit a signal. Second, we create a VI that can receive a signal. Next we use signal processing tools to compare the received reflected signal against the transmitted one in order to determine frequency shifts in the signals. The last thing to do is output the change in signals using peak values in the magnitude of the received signal, to display when movement is detected by the system. Programmable USRP radios weigh less and cost less compared to current technologies that utilize radar to detect movement, and can be programmed to send a signal through the wall and receive the reflection as it bounces off an object on the other side. Furthermore, the advantage of using USRP devices is that they are programmable and operate in license free Industry, Scientific and Medical (ISM) bands - 2.4 to 2.5 GHz and 4.9 to 5.85 GHz.

The main idea of through wall imaging is to capture the reflection response of a signal as it travels through a medium. If the signal is traveling through the medium and suddenly reflects back toward the source, it can be determined that something was there and disrupted its path. Skin depth of a signal is a good measure for how far into a medium a signal should penetrate; because of the nature of signals and systems, the depth and material type of the wall we plan to send the signal through is very important (Bevelacqua, 2015). If we use too much power then the object could essentially be missed by the transmitted signal; at the same time this concept of skin depth also helps us by cancelling out the probability that the object is not a person.

The first major concept that allows for the radios to track movement is to compare the delay of the received signal compared to the signal that was sent; in this manner it is possible to determine that the signal was sent out and came back to the receiver at a different frequency shift. Then the two signals are correlated using signal processing techniques and the output peaks that rise from the differences in the signal are displayed. Another important concept is the ability to determine the difference between a person and an inanimate object; this is done by monitoring the amount of power absorption. When the signal is sent through the medium, it hits the target and comes back to the USRP device, there will be significant power absorption and loss from the beginning to the end. We will be able to tell based on the estimated amount of lost power if the object absorbed more or less than a typical human body (Bevelacqua, 2015). Another challenge to focus on is the flash effect from signal readings, directing the signal using Multiple Input Multiple Output (MIMO) methods, and differentiating between wall interference readings and target objective measurements ('surveillance device uses Wi-Fi to see through walls - CNET' 2012). This is expanded more on this same solution while programming the USRP in LabVIEW using built in functions to render the target's location. Another concept is angular positioning to determine the target's location and depth inside the room; we use the projected radio signal and based on the angle of the reflected signal we generate a "bird's eye view" of the room (Bevelacqua, 2015, Xu et al, 2016).

In this paper, we develop through-wall virtual imaging using Wi-Fi enabled software defined radio to see moving objects and their relative locations. We use LabVIEW and NI Universal Software Radio Peripheral (NI USRP2921 radios (Younis, 2016; Rawat, 2015) with Ettus Research brand LP0965 directive antennas) devices to virtually detect moving objects behind the wall by sending and receiving a signal with respect to USRP's location. We evaluate the performance of the proposed approach using experimental results by considering different scenarios.

The remainder of this report is as follows: Section 2 presents the preliminary design, Section 3 presents solution description, Section 4 deals with performance optimization, Section 5 presents project implementation and evaluation, and Section 6 concludes the paper.