Modelling of reflection of UWB pulses from trapped human beings

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In emergency situations detection of (un)concious human beings buried under rubble or hidden behind thick smoke is of great importance. There are several approaches for solving the problem: IR camera, which exhibits limitations in NLOS situations or in presence of strong surrounding heat, or use of radars: Doppler, interferometry or UWB radar. In this paper, we are evaluating the use of UWB pulses for human breathing detection purposes.

The idea of human breathing detection using UWB radar is to observe periodic differences in time-of-arrival of scattered pulses from the victim, which result from periodic movements of the chest area of the victim. One of the main problems faced in human breathing detection using UWB radar is the low SNR values associated with it, which makes detectability difficult. A way to improve the SNR is to perform matched filtering in the receiver. It is therefore desirable to have a template which matches the scattered pulse as much as possible. In this paper we analyse how changes in thickness and conditions of body layers influence the shape of the scattered pulse and effectively the need of accurate matched filter template. Since, obviously, more bandwidth results in higher resolution and thus facilitates breathing detection, but at the same time increases interference to other systems, it is further important to investigate what the minimal bandwidth and optimal centre frequency should be for successful breathing detection.

To simulate scattering of UWB pulses from a human body we have developed a simple one-dimensional computer model of the cross-section of the human chest. The output of simulations has been used for evaluation of human being detectability using UWB radar. The detectability is determined and evaluated by a developed human breathing detection algorithm. The number and the thickness of the human tissue layers in the model are realistically modelled and their dielectric permittivity is frequency dependent. Breathing is then simulated by periodically changing the thickness of the lung layer. Simulation results are verified by experiments in which an UWB radar illuminates a person under test (PUD) facing the radar.

From simulations we have found that the penetration is higher for lower frequencies (up to a couple of GHz) and reaches a higher and constant value for higher frequencies. The skin and fat layer have the highest impact on the pulse shape. Correlation between transmitted and received pulses have been analysed for various pulse widths in order to see to what degree the pulse shape has changed due to reflection. Simulations and experimental verification on necessary bandwidth and optimal centre frequency are expected soon.