Human breathing detection algorithm for UWB radar aided victim search

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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, an algorithm is presented for human breathing and victim position detection using UWB radar. 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 are result of periodic movements of the chest area of the victim. The main problem faced is that the SNR and the SCR (signal-to-clutter ratio) are generally very low. That is the reason that an algorithm that detects periodic motion of weak signals is needed. The data for evaluation of the algorithm is collected using an UWB radar, which consists of a short-pulse generator, stroboscopic oscilloscope, two TEM-horn antennas and a control PC. The transmitted power is in the order of microwatts. The radar illuminates a person under test (PUD) hidden behind rubble or a wall with an acquisition frequency of averaged range profiles more than two times the breathing frequency, in order for it to be resolvable. Clutter, as long as it is stationary, is not a limiting factor since it can be estimated and removed. The limiting factor is SNR. One way of increasing it is performing out-of-band filtering and, during the data collection, averaging a number of consecutive range profiles that are acquired under a very short period of time. FFT is then taken over time, i.e. across the range profiles, for each of the range profile samples. This results in a peak corresponding to the breathing frequency of the PUD and positioned at the range where the PUD is located. In order to further improve SNR, a model of distribution of breathing frequency is adopted, where Gaussian distribution with an expected breathing frequency m_b and standard deviation σ_b is assumed. The two parameters are empirical values obtained from observations of human breathing. The Gaussian window is applied after FFT, and the energy summed in time dimension, resulting in an energy profile as a function of range. A peak in the energy profile is found positioned at the range where the breathing victim is located. In order to distinguish between a case with victim present from a "no victim" case, a threshold is computed by taking the mean of the energy profile. Any peak in the energy profile that is L dB higher than the threshold is assumed to correspond to a breathing human being. The value of L is set so that it takes into account the range dependency of signal power, thus resulting in a nearly constant detection probability as a function of range and range dependent false alarm rate. Simulation results with real recorded noise, clutter and body response, show that detection is possible for SNR values as low as -6.6 dB. Experimental results show that detection of human breathing is possible for the PUD facing the radar and being located behind two 10 cm thick concrete walls.