ON RESPIRATION-RATE ESTIMATION USING IMPULSE-BASED ULTRA-WIDEBAND (UWB)

S. Venkatesh, C. R. Anderson, N. V. Rivera , R. M. Buehrer
Mobile and Portable Radio Research Group (MPRG), Virginia Tech, Blacksburg, VA 24060, USA.

Abstract Submission Form

2006 National Radio Science Meeting

Abstract: venkatesh10554

Date Received: September 8, 2005

1. (a) Swaroop Venkatesh
440 Durham Hall, MPRG
Virginia Tech
Blacksburg, VA
24060 USA
vswaroop@vt.edu
(b) 1-540-231-9943
(c)

2. K - Electromagnetics in Biology and Medecine

3. (a)

4. C - Contributed Paper

5. No special instructions

The non-invasive monitoring of respiration-rate has potential applications in health monitoring, hostage rescue, triage and athletic performance monitoring. The use of impulse-based UWB signals in the robust detection of chest-cavity motion and the accurate estimation of respiration and heart-beat rates, even in the presence of physical obstructions between the subject and the UWB antennas, was demonstrated in [1]. Signal processing algorithms were developed to estimate respiration and heart rates and their accuracy was demonstrated using measurements.

The coefficient of reflectivity of air-to-dry-skin interface for electromagnetic waves in the 300-900 MHz range is about 72%. Due to this, and the high spatial resolution of UWB signals, the motion of a human body can cause observable changes to the multipath profile. It was shown that [1] the expansion of the chest cavity creates an significant variation in the measured multipath profile, which is exploited to estimate the respiration and heart rates.

A problem fundamental to the modeling of respiration and heart-rate estimation is the estimation of the frequency of a single-tone in additive-white Gaussian noise (AWGN), given discrete-time samples over a finite measurement interval. It can be shown that the algorithm derived in [1] represents the Maximum-Likehood (ML) estimator [2] of the respiration rate, which, for large data sets and "high" signal-to-noise-ratios, approaches the Cramer-Rao lower bound. In the current work, the performance of this estimator is analyzed in UWB propagation environments, and results of the application of these methods to real measured data are presented.

Due to the time-sensitive and non-invasive nature of the aforementioned applications, the total measurement time needs to be minimized while ensuring that the respiration-rate estimate is sufficiently accurate. An investigation into the resulting trade-offs and the computation of "optimal" measurement times is also presented.

## References

[1] S. Venkatesh, C.R. Anderson, N. V. Rivera, R. M. Buehrer, "Implementation and Analysis of Respiration-rate Estimation using Impulse-based UWB", *To appear in the Proceedings of the 2005 IEEE Military Communications conference (MILCOM 2005).*

[2] D. Rife and R. Boorstyn, "Single tone parameter estimation from discrete-time observations", *IEEE Transactions on Information Theory*, vol. 20, no. 5, pp. 591 - 598, September 1974.