Experimental study on super-resolution techniques for high-speed UWB radar imaging of human bodies

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UWB (Ultra Wide-Band) radar systems are used in a variety of applications including security surveillance systems. The fast UWB radar imaging algorithm SEABED [1, 2], is, however, the only method that can be used in applications demanding real-time operation, such as surveillance. The SEABED algorithm is based on a reversible transform IBST (Inverse BST) between the target shape and a time delay observed at multiple locations. Because the IBST is incredibly sensitive to the resolution of the time delay, it is imperative that high-resolution data is obtained to estimate various parts of the human-body. Although the resolution of radar is basically restricted by its bandwidth, super-resolution techniques have been applied to GPR (Ground Penetrating Radar) to enhance the conventional resolution limit [3]. In this paper, we investigate experimentally super-resolution techniques for UWB radar data using a pig's anterior abdominal wall as a model of the human body. The results show that the super-resolution techniques are indeed capable of improving the performance of the SEABED algorithm.

Figure 1 shows the experimental UWB radar site in an anechoic chamber. The system includes a short pulse generator, a pair of omni-directional wideband planar patch antennas, and a wideband oscilloscope. The transmitted pulse has a center frequency of 3.7GHz and bandwidth of 3.0GHz, of which the classical range resolution is about 50mm. As seen in the figure, the pair of antennas are positioned above the pig's anterior abdominal wall. The two antennas are scanned in a straight line and the received signal is recorded every 5mm.

The MUSIC algorithm is applied in the frequency domain to enhance the resolution as in [3]. First, we select $2M-1$ frequency-domain data samples with S/N larger than -20dB, where the maximum power density is 0dB, and $M = 70$ is empirically chosen. Next, a frequency smoothing technique is applied to resolve correlated interferences, where $M \times M$ covariance matrices are averaged M times. Then, an eigenvalue decomposition is applied and a MUSIC spectrum produced for each antenna location assuming a 2-dimensional signal subspace. Figure 2 shows the estimated image, in which a clear target boundary is visible with a high resolution of about 10mm. This is 5 times higher than the classical resolution of 50mm. This super-resolution technique can be employed in conjunction with the SEABED algorithm to obtain a detailed structure of the human body.

Figure 1: Experimental site for UWB radar with an anterior abdominal wall.

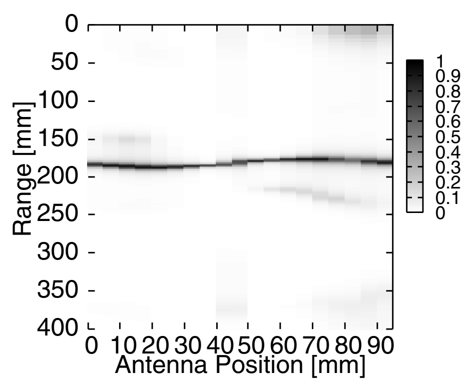

Figure 2: Super-resolution image of the surface of an abdominal wall.

References

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