Hard Wall Radar Imaging: Localization of Multiple Objects Shadowed by Metallic Walls with Bistatic Mode MIMO Radar System

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"Through-Wall Radar Imaging" (TWRI) has been studied extensively to reconstruct the image from the backscattered waves through the opaque dielectric wall. When the objects are located in the shadow region of the metallic wall (hard wall) where the waves can only bypass the wall via diffraction, a new problem arises as "Hard-Wall Radar Imaging" (HWRI), which has been proposed and discussed in our previous papers.

In our previous numerical and experimental studies, time reversal imaging technique DORT (Decomposition of Time-Reversal Operator) was utilized with the new multiplicative array processing and entropy focusing technique. However, it has been found that this imaging technique is not so practical because of a low signal-to-clutter ratio (SCR) which is mainly due to the small diffracted fields and a large amount of reflections from clutters at microwave frequency. The low SCR results from the low gain of transmit/receive antennas which are designed for the measurement of multistatic data matrix (MDM) with a wide angler response.

In this paper, this problem is resolved by improving our microwave imaging system: the bistatic mode MIMO configuration is used with two pyramidal horn antenna as an illuminator and a six element dual-polarized planar Bowtie slot array as receivers. In the new imaging system, the software gating system is utilized with the stepped continuous wave frequency spanning from 1.5 GHz to 3GHz.

The interelement response matrix is collected by controlling microwave multiplexing circuits. The covariance matrix is constructed to obtain the Direction of Arrival (DoA) and the geometry of hard wall using MUSIC(multiple signal classification) technique. Next, the adaptive nulling technique is applied to suppress the interference terms in the image function due to the multipath of backscattering. After having obtained the round-trip steering vector from the estimated geometry of imaging scenario and geometric theory of diffraction (GTD), the model-based image function is re-formularized to a bistatic mode for outputs of adaptive nulling receive array. It has been shown that two resolvable point targets can be clearly localized for several cases. Moreover, the range resolution, minimum distance between objects, and physical limitations of classifying object shapes are analyzed for this imaging scenario in addition to imaging results.