Array Coherence Tomography (ACT) imaging in clutter environment

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We present a new antenna array signal processing technique which we name ACT (Array Coherence Tomography) applicable to wireless communications. ACT is based on OCT (Optical Coherent Tomography) which is one of the exciting developments in medical optics in the last decade [1-6]. OCT can provide tissue images on the micro scale *in situ* and real time and has been developed as diagnostic technology for disease tissues and eyes. OCT combines confocal microscopy and hetrodyne technique, and one of its advantages is its ability to form a high-resolution image in the presence of diffusing tissues.

In this study, we apply the OCT technique to microwave array imaging sensors. This approach is new, and we expect an improved high-resolution image of objects in a clutter scattering environment. The core of the array coherence tomographic imaging (ACT) technique that we developed is as follows. Let r_m (n = 1, ... M) be the location of M transmitters. Let r_n (n = 1, ... N) be the location of N receivers. The location of the target is r_t and r_s (s = 1, ... S) is the location of s cluttering scatterers (Fig. A).

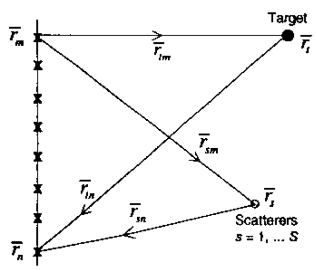

Fig. A: Transmitters at $\bar{r}_m$ (m = 1, ... M), receivers at $\bar{r}_n$ (n = 1, ... N), target at $\bar{r}_t$, and scatterers at $\bar{r}_s$ (s = 1, ... S).

The signal is the coherent sum of all received signals and given by

$$X = \sum_{m=1}^{M} \sum_{n=1}^{N} X_{mn}$$

where X_{mn} includes the transmitter spectrum, Green's functions, and the scatterer characteristics. At the receiver, we apply the focusing (or steering) processing Amn which includes the hetrodyne signal and focusing functions.
The coherent received power P is then given by

$$P = \left\langle \left| \frac{1}{2\pi} \int d\omega [A]^{+} [X] \right|^{2} \right\rangle$$

where + is the "transpose conjugate", and < > is an ensemble average. This new formulation is a generalization of SAR and confocal imaging. We used UWB (ultra-wideband) and chirp signals and obtained excellent results which are superior to conventional SAR and confocal imaging (Fig.B).

In the above formulations random distributions of cluttering scatterers tend to average out and reduce the diffuse component resulting in sharper images, similar to OCT.

The technique can be also applied in conjunction with other array processing technique such as Capon's method. We present a detailed theory and calculations of ACT method applied to communication in clutter environment.

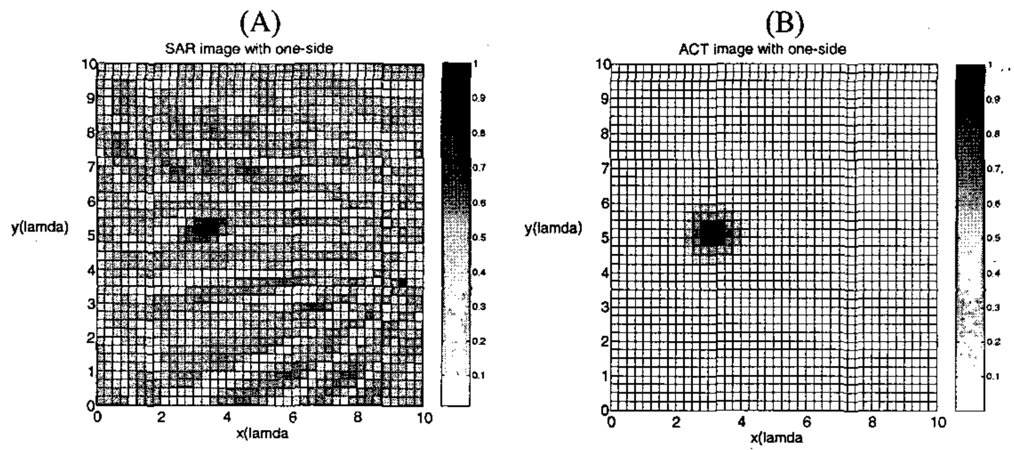

Fig. B: Point source imaging through discrete random scatterers using (A) SAR and (B) proposed ACT.

Reference

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