A Simple Polarization Diversity Technique for Radar Detection

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I. EXTENDED ABSTRACT

There are many proposals for multi-channel radar, emanating from the conventional *monostatic* radar system where transmitter and receiver are collocated. Collocation makes it easy for transmitter and receiver to share a common stable clock (local oscillator), which is required for both range and Doppler measurements. Signal processing for multi-static radars (see [1]) with widely dispersed antenna elements is currently a very active research area, in part because of significant advances in hardware capabilities. Multi-static radar enables multiple views of the scene, and a (wide angle) tomographic approach to the recovery of the scene from the data. A major advantage of multi-static radar is substantial improvement in detection due to multiple views of the target being available. When system elements are widely dispersed, the coherent implementation of multi-static radar is rendered difficult by the problem of clock synchronization. An additional challenge is the degree of computation necessary to recover the scene, or detect a target, by integrating multiple views.

It is natural to approach multi-channel radar in terms of spatial diversity concepts developed for multiple-input-multiple-output (MIMO) communications ([3], [2]). Performance improvements in MIMO communications derive from spatial diversity, that is, the statistical independence of the different channels provided by the multiple antenna elements. Fishler *et al.*[3] correctly point out that sufficiently separated system elements do give rise to statistically independent views of the target. However, in their analysis of detection performance, they assume a target in the far-field by invoking a “narrow band” approximation which necessarily implies complete statistical dependence across the distributed antennas. Without the narrow band approximation, the analysis reduces to that of conventional multi-static radar systems.

An important difference between wireless communication and radar sensing is that, in communication, timing information is shared between the base station and the mobile terminal. This is not the case in radar, where the primary objective is often to learn the timing, since this is the range of the target. Since radar applications spend no time communicating data and all the time learning the channel, this represents an enormous opportunity for waveform design as demonstrated by the literature on this topic [3], [4], [5], [6], [7]. The introduction of multiple antennas increases the degrees of freedom in the waveform design space.

Target scattering profiles depend significantly both on aspect angle and illumination and receive polarizations (see Skolnik Section 2.7, [8]). Here we propose an approach to MIMO radar that uses polarization to provide essentially independent channels for viewing the target. Polarization diversity enables detection of smaller radar cross section (RCS) targets, and avoids the physical, mathematical, and engineering challenges of time-of-arrival coherent combining. The advantage of polarization diversity over spatial diversity is that diversity gains are possible with collocated antennas. We employ Golay pairs [9] of phase-coded waveforms to provide synchronization and enable use of the Alamouti space-time block code [10]. This triple play of polarization, Golay technology, and Alamouti codes has the potential to significantly improve the performance of any conventional polarimetric radar.

We have compared the new scheme to a conventional single polarization channel radar and have shown that, for an idealized point target model and for reasonable values of probability of detection, it gives equivalent performance to the base-line system for substantially smaller transmit energy, or alternatively, allows detection at substantially greater ranges for a given transmit energy. In future work we expect to use experimental data to derive more realistic scattering models.

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