Reconstructing Analog Waveforms Sensed in Reverberant Environments

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Radio frequency waveforms emitted in remote sensing applications are distorted by electromagnetic interactions with their propagation environments, often quantified with a *channel matrix* in the communications literature. Feature extractor and pattern classification algorithms must accept these waveforms and assign reliable class labels despite the distortion and random noise. The feature extractor often bears the brunt of this challenge, rather than the classifier itself, by exploiting domain knowledge such as the channel matrix. In contrast to many communication systems, a remote sensor may employ wide bandwidth vulnerable to frequency-selective fading. Furthermore, a remote sensor rarely enjoys cooperation with its target. Consequently, established techniques for characterizing the channel matrix in communication systems, such as using training sequences, are unavailable for remote sensing systems. Here, we show an alternative estimation of the channel matrix suitable for wideband, reverberant environments. The model assumes that the channel impulse response is the linear superposition of component responses, each the particular response of a resonant eigenmode of the propagation environment.

Relying on the assumption that eigenmodes are shared across the propagation environment, their complex eigenvalues are estimated using a training sequence transmitted not from the uncooperative target, but rather a second *cooperating* transmitter somewhere else in the environment. Ultimately, uncertainty in the estimated channel matrix is confined primarily to the unknown coupling of the target to each particular mode.

We do not attempt to demonstrate an actual feature extractor or classifier algorithm here. Rather, we scope just the proposed fading model and compare known emitted waveforms to their remote sensed, reconstructed versions using the estimated channel matrix. For this initial result, we guarantee the assumption of an eigenmode dominated channel matrix by collecting data in a reverberation chamber.