Demonstration of Multivariate Photonics: Blind Dimensionality Reduction With Integrated Photonics

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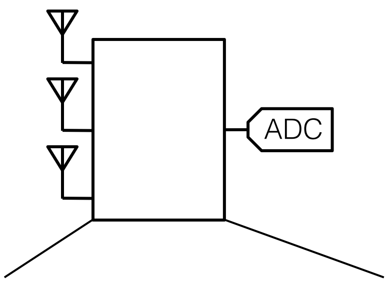
ADC

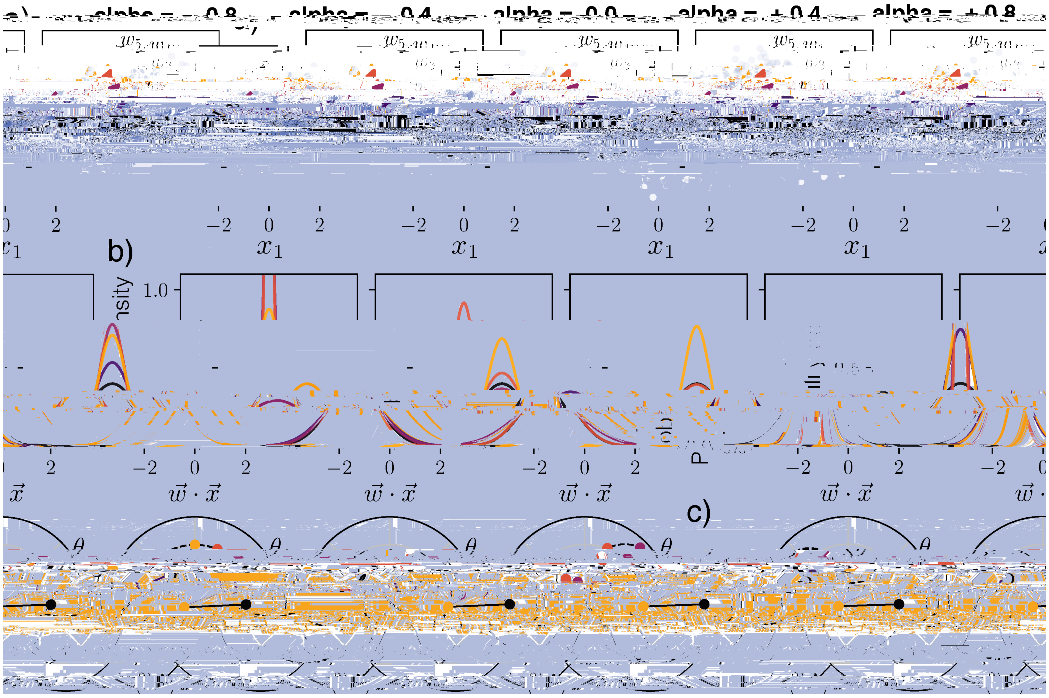

Fig. 2. Visual interpretation of projected bivariate statistics over 5 values of cross-correlation, α. (a) Blue points: synchronously sampled 2-channel signals x t

TABLE I
RMS VALUES IN MILLIVOLTS OF SIGNAL, NOISE, AND ERROR FOR BOTH PCS OVER THE RANGE OF CORRELATION VALUES EVALUATED. PERCENT ERROR IS RATIO OF ERROR TO SIGNAL. THE NOISE-ERROR RATIO INDICATES THAT MEASUREMENT NOISE CONTRIBUTED SIGNIFICANTLY TO ERROR

$\hat{\alpha}$	α	PC#

B. Scalability

One source of scaling limits stems from photonic weight bank hardware. The number of dimensions is limited by resonator finesse and a penalty related to the ability to weight neighboring channels independently, derived in [39] and determined to be 1.2 in [60]. is limited by resonator FSR and a distortion penalty measured in [61] to be 4.3. Ref. [62] showed oxide-clad microdisks with FSR of 57 nm (7.1 THz) and -factor of 80 k, resulting in finesse of 2900. This means that multivariate photonic circuits using these resonators and WDM could scale to 1500 and 1.65 THz. There are other forms of multiplexing besides WDM, such as mode- and polarization-division multiplexing, that would further increase both of these limits.

Scaling limits could also stem from algorithms. The model of projection moment vs. projection angle, Eq. (3), can be straightforwardly extended to higher dimension by introducing additional angle variables; however, it is unclear whether the model-based fitting method can still extend to higher dimensions in the presence of noise. For each additional dimension, two model parameters and thus two additional measurements are required. The fit quality can be improved by taking more than the minimum number of measurements or by averaging for longer per measurement. Further work might be able to determine if there is a limit to this approach or to develop other ways to exploit the information derived from measurements of statistical moments.

There is also a question of how much need there is for a large number of antennas in actual applications. Today's WiMAX signal processing, particularly for multi-dimensional (e.g. multi-antenna) tasks.

Dimensionality reduction underlies blind source separation, a widely desired capability in wireless systems that presents a significant information processing challenge. Moving dimensionality reduction to the analog domain can break harsh performance tradeoffs associated with analog-to-digital conversion; however, it also constrains the type of information that can be observed.

A new type of algorithm based on measurements of statistical moments was developed to work within realistic constraints on waveform observability. Here, it was evaluated on photonic hardware using novel experimental techniques to enforce realistic conditions of observability in a lab. The concepts and methods demonstrated lay a groundwork for experimental research into multivariate photonic algorithms, hardware, and applications.

Note: This paper is a significant revision of the preprint in [64]. Since submission of this paper, a follow up to that preprint and this paper was published in [65], which answers several of the calls for further work above.

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