Parameter Estimation Techniques for Multi-component Polynomial Phase Signals

1. Problem Formulation

The problem is how to characterize parameter estimators for multicomponent polynomial phase signals used as active sensing waveforms to study information processing aspects associated with the spatio-temporal dynamics of finite dimensional systems.

A time-frequency signal is defined as a signal whose spectral distribution changes with time. Chirp signals are time-frequency signals which are linearly frequency modulated and are widely used in RADAR applications. Discrete Chirp Fourier Transform (DCFT), Cyclic Short Time Fourier Transform (CSTFT), and other transforms such as Ambiguity Function make possible detection and estimation of parameters in multicomponent chirp signals arising from point targets.

2. Theoretical Framework

Discrete multi-component polynomial phase signal (mC-PPS) is expressed as follows:

\[ x[n] = \sum_{k=0}^{K-1} A_k \cdot e^{i \sum_{m=0}^{M-1} \alpha_m n^m} + \rho[n], \quad n \in \mathbb{Z}_N \]

Where, \( K \) and \( M \) are positive integers, \( A_k \) are complex scalars, \( \rho \) is a discrete noise signal or interference signal, and \( \alpha_m, k \in \mathbb{Z}_K, m \in \mathbb{Z}_M \) are the parameters to be estimated.

3. Results

Cyclic Short Time Fourier Transform (CSTFT)

Experimental results for a DCFT transform with input of a 6 component Chirp Signal and white noise (zero mean, \( \sigma^2 = 1 \)):

- Successful Estimation (SNR: 6dB)
- Unsuccessful Estimation (SNR: 3dB)

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4. Conclusions and Future Work

- T-F representations extract information of the input signal, but this have a cost. The estimator implementation involves high computational complexity.
- Implementation of estimators such as DCFT, CSTFT can be used to estimate the parameters of the mC-PPS.

5. References