T2: Applications of Polynomial Eigenvalue Decomposition to Multichannel Broadband Signal Processing

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AUM

EUSIPCO2023

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Monday, 04 Sep 2023

Outline

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Motivations of PEVD

Motivations of PEVD

Multichannel broadband signals arise at the core of many technologies

- Commercial: seismic, speech, telecommunications
- Military: radar, sonar, communications

Processing approaches include

- Splitting broadband into multiple narrowband signals
  $\Rightarrow$ Ignores spectral coherence and correlations between frequency bands
- Classical subspace methods use the (instantaneous) spatial covariance matrix
  $\Rightarrow$ Inadequate for convolutively mixed and/or broadband signals

Promising Approach: Polynomial Matrix Eigenvalue Decomposition (PEVD)

Brief History of PEVD

Brief History of Polynomial Matrices and PEVD

- Polynomial matrices are used in multivariable transfer functions in the control domain, e.g. Smith and Smith-McMillan forms, where the critical design issue is time delays [Kailath 1980] .
- Within signal processing, polynomial matrices are used in polyphase analysis and synthesis in filter bank theory [Vaidyanathan 1993] .
- For signal processing, energy preservation (unitarity) of a transform which can diagonalize an analytic matrix is more important.
- This motivated the development of the PEVD algorithm, second-order sequential best rotation (SBR2) [McWhirter2007] .

PEVD Tutorial Outline

Outline of This PEVD Tutorial

1. Part I: Background
2. Part II: Eigenvalue Decomposition
3. Break
4. Part III: Subband Coding via Polynomial EVD
5. Part IV: Speech Processing Applications
6. Part V: Concluding Remarks and Closing

Applications of PEVD

Applications of PEVD

The following list contains some examples of PEVD applications:

1. Beamforming [Weiss2015; Neo2022a]
2. Communications [Brandt2011; Hassan2019; Hassan2021]
3. Direction of Arrival Estimation [Alrmah2011; Weiss2013; Hogg2021]
4. Speech Enhancement [Neo2021a]
5. Source Separation [Redif2017; Redif 2017; Neo2021b]
6. Source and System Identification [Weiss2017; Khattak2022]
7. Subband Coding [Redif2011]
8. Weak Transient/Voice Activity Detection [Weiss2021; Neo2022c; Neo2022b]

PEVD Enthusiasts

Who We Are

Imperial College London

Vincent W. Neo
Research Interest: Multichannel signal processing and PEVD with applications to speech, audio and acoustics

Soydan Redif
Array and adaptive signal processing applied to source separation, comms, power, biomedical, and wearables

Stephan Weiss
Adaptive, multirate and array signal processing with applications in audio, acoustics, comms, and biomedical

Patrick A. Naylor
Microphone array signal processing, speaker diarization, and multichannel speech enhancement

Fellow PEVD Enthusiasts

John G. McWhirter

Independent component analysis for blind signal separation and polynomial matrix algorithms for broadband array sensor signal processing

Ian K. Proudler

Adaptive filtering, adaptive beamforming, multichannel signal processing and blind signal separation

Jennifer Pestana

Numerical linear algebra and matrix analysis and their application to problems in science and engineering

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