Supplementary material for TFSAP book Section 13.3: "Eigenfunctions of Underspread Linear Time-Varying Systems"[1]

The additional material[2] in this file is provided by Prof Boashash to assist the reader to better understand Section 13.3 of the TFSAP book.

A. Supplementary Codes:

The MATLAB scripts listed below are used to produce supporting figures for Section 13.3.

MATLAB Script:

Example_1.m

- Description: This script produces results that are similar to the ones depicted in Fig. 13.3.2, on page 765 of the book.
- Process: It computes the time-frequency distribution (TFD) of a channel response using Eq. (13.3.18), on page 764 of the book. After that, it decomposes the TFD using singular value decomposition (SVD), and finally, reconstructs different TFDs using selected parts of the decomposed distribution.
- Note: The utilized parameters were selected w.r.t. to the random seed "`rng(1)`", other seeds require further parameter adjustments.

Example_2.m

- Description: This script produces results that are similar to the ones depicted in Fig. 13.3.4, on page 767 of the book.
- Process: It computes the TFD of three prolate spheroidal sequences corresponding to three different singular values (decreasing from top to bottom).
- Note: TFSAP Toolbox[3] should be installed.

B. Additional Related Supplementary Materials from Other Chapters:

The reader may also benefit from accessing the code and/or other supplementary materials provided in the following related Chapters of the book: *I*.2.2, 1.3.1, 3.5, 2.1.3, 2.1.4, 6.2 and 17.3.5, as detailed below.

1. Related Supplementary Material in Chapters *I*.2.2 and 1.3.1:

The instantaneous bandwidth (IB) and the instantaneous frequency (IF) are introduced and defined in Chapters I.2.2 and 1.3.1. Run the MATLAB script *clchirp.m*, provided in the SM of

[1] B. Boashash, Ed., "Eigenfunctions of Underspread Linear Time-Varying Systems", Supplementary material for Chapter 13.3; in B. Boashash (ed.), *Time-Frequency Signal Analysis and Processing*, 2nd Edition (London: Elsevier / Academic Press, pages 760-769, December 2015); ISBN 978-0-12-398499-9.

[2] All of the book supplementary materials can be found here.

[3] TFSAP Toolbox can be found here.

Chapter I, to produce Fig. I.2.3 on page 17 of the book, where it illustrates the interpretation of the IF and IB of a linear frequency modulated (LFM) signal.
Furthermore, run the MATLAB script *gaussch.m*, provided in the SM of Chapter 1, to produce Fig. 1.3.2 on page 54 of the book, where it shows the IF estimation of an LFM signal.

2. Related Supplementary Material in Chapter 3.5:

The meaning of Ambiguity Function (AF) is discussed in Chapter 3.5 in the context of a simple radar experiment. To compute the AF of an input signal using the TFSAP Toolbox in the user's own code, call the function `ambf` in the MATLAB command window as shown below.

```
af = ambf(signal, lag_res, window_length );
```

Inputs:
signal = Input one dimensional signal to be analyzed.
Lag_res = number of lag to skip between successive slices.
window_length = number of signal samples used for analysis.

Output:
af = ambiguity function representation.

For more details, see the help of function *ambf* by typing `help ambf` in the MATLAB command window.

3. Related Supplementary Material in Chapters 2.1.3 and 2.1.4:

Formulations of the Wigner and the Wigner-Ville distributions are presented in Chapters 2.1.3 and 2.1.4 and illustrated in Figs. 2.1.1 and 2.1.2 on pages 68 and 69 of the book. Run the MATLAB scripts *WVD_lfm_signal.m* and *WD_and_WVD.m* to reproduce the results.

4. Related Supplementary Material in Chapter 6.2:

Discrete realization of the Pseudo Wigner-Ville distribution (PWVD) is illustrated and explained in Chapter 6.2. Run the MATLAB script *Figure_2.m* to produce Fig. 6.2.2 (b) on page 347 of the book, where it shows the time-frequency representation of a real-valued multicomponent signal using the PWVD.

5. Related Supplementary Material in Chapter 17.3.5:

Quadratic Time-Frequency distributions, e.g. the WVD, of a time-domain signal can be computed and plotted by accessing the functionalities of the TFSAP Toolbox either by using the GUI model or by using the MATLAB command window (see Section 17.3.5 of the SM of Chapter 17).

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